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Adrià Jorba-Garcia, DDS, MS, PhD
Oscar Gonzalez-Martin, DDS, MSc, PhD
Leandro Chambrone, DDS, MSc, PhD
Manrique Fonseca, Dr med dent, MAS
Emilio Couso-Queiruga, Dr med dent, DDS, MS

Management of Peri-implant Mucosal Dehiscences: A Scoping Review

Several treatment-oriented classifications for the management of peri-implant marginal mucosal defects (PMMDs) have been published to date. While each classification provides valuable insights into key diagnostic and therapeutic aspects, there is a marked heterogeneity regarding the recommended clinical guidelines to achieve success in specific scenarios. The purpose of this review was to critically analyze and organize the similarities and differences enclosed in the available classifications linked with treatment recommendations on the management of PMMDs at nonmolar single-implant sites with the purpose of providing an overview of recommended interdisciplinary treatment options to facilitate clinical decision-making processes. *Int J Periodontics Restorative Dent 2025;45:673–687. doi: 10.11607/prd.7257*

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Implant therapy has consolidated over the past several decades as a predictable and popular option among healthcare providers and patients alike for the replacement of missing teeth.[1] Through adequate case selection, treatment planning, technical execution, and a personalized maintenance plan, implant therapy can be associated with highly satisfactory long-term functional and esthetic outcomes.[2–5] However, implant therapy is not exempt from complications, some of which may result in the development of structural deformities of the peri-implant hard and soft tissues.[6–9]

Considering the soft tissue-related components of the peri-implant phenotype (ie, keratinized mucosa width, mucosal thickness, and supracrestal tissue height),[10] proximal and nonproximal deformities of the peri-implant mucosa can be broadly categorized as[11]: keratinized mucosa width deficiencies, peri-implant mucosal thickness deficiencies, and peri-implant marginal mucosa defects. Although these are evidently three distinct clinical entities that may be associated with different causal factors, it is not uncommon to observe them in concomitance.[12]

Among them, peri-implant marginal mucosa defects (PMMDs), also known as *peri-implant soft tissue dehiscences* or *peri-implant mucosal dehiscences*,[13] have been defined as alterations of the peri-implant soft tissue architecture characterized by an apical discrepancy of the mucosal margin respective to its ideal position, with or without exposure of transmucosal prosthetic components or the implant surface.[14] PMMDs have a multifactorial etiology, as they may be caused by true mucosal recession (ie, apical migration of the mucosal margin) due to, for example, inflammatory disease, sustained trauma, and/or iatrogenic dentistry (active pattern); by progressive peri-implant marginal mucosa discrepancies respective to the adjacent gingival tissue as a result of lifelong craniofacial growth (passive pattern)[15,16]; or by a combination of both.

Several treatment-oriented classifications have emerged based on the topographic characteristics of soft tissue defects, linking them to clinical management recommendations with the ultimate goal of optimizing the therapeutic outcomes.[13,14,17–19] Nevertheless, among the available studies on the management of peri-implant soft tissue deformities, there is limited information on the differences/similarities between proposed treatment-driven classifications. Thus, this review aimed to compile and critically analyze the similarities and differences enclosed in the available classifications linked with treatment recommendations for PMMD management at nonmolar single-implant sites, aiming to provide an overview of recommended interdisciplinary treatment options to facilitate clinical decision-making processes.

Materials and Methods

This scoping review was structured according to the Joanna Briggs Institute method[20] and the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) statement.[21] The review protocol was registered in advance in PROSPERO.

The focused research question of this review was: "In the management of PMMD at single implants in the anterior esthetic zone bound by natural teeth, what are the similarities/differences among the classifications linked with treatment recommendations available in the literature?

Eligibility Criteria

For the inclusion criteria, eligible studies must involve classifications linked with treatment recommendations on the management of buccal PMMDs in the anterior esthetic zone in implants bound by natural teeth that do not exhibit peri-implantitis. Studies reporting on the management of peri-implant disease defects or multiple implant-supported prostheses (ISPs) were excluded. No language or publication date restrictions were applied.

Information Sources and Search Strategy

Four electronic databases were searched—the National Library of Medicine (MEDLINE/PubMed), Cochrane Central Register of Controlled Trials (CENTRAL), Scopus, and Web of Science—using specific strategies (Table 1). The last electronic search was conducted on April 29, 2024. The gray literature was also searched. Additionally, to complement the database search, a thorough hand search was performed by screening the bibliographies of the identified articles as well as a systematic review published on this topic.[9]

Selection Process

Two independent authors (A.J.G. and E.C.Q.) performed the search and read the title and abstract of entry obtained from the literature searches and made a preliminary selection. Then, both reviewers individually read through the full-text versions of the potentially eligible studies. Final article selection was performed. When disagreement occurred regarding the inclusion of a specific article, both reviewers had an open discussion to make the final decision. Following article selection, Cohen's kappa coefficient (k) was calculated to determine the degree of interexaminer agreement.

Data Extraction and Synthesis

Extracted data were organized into evidence tables by two independent examiners (A.J.G. and E.C.Q.) and divided into four main categories: study

Table 1 Search Strategy for Each Database

Database	Search	Articles, n
PubMed	("Classification"[Mesh] OR "Decision Trees"[Mesh] OR "classification" OR "decision tree" OR "guideline") AND ("Dental Implants"[Mesh] OR "Dental Implants, Single-Tooth"[Mesh] OR "Dental implants" OR "peri-implant") AND ("esthetic complications" OR " soft tissue dehiscences" OR " soft tissue deficiencies" OR "mucosal marginal defects" OR "recession" OR "deficiency" OR "defect" OR "dehiscence" OR "soft tissue" OR "esthetic complications")	265
Scopus	TITLE-ABS-KEY (("classification" OR "decision tree" OR "guideline") AND ("Dental implants" OR "peri-implant") AND ("esthetic complications" OR " soft tissue dehiscence" OR " soft tissue deficiencies" OR "mucosal marginal defects" OR "recession" OR "deficiency" OR "defect" OR "dehiscence" OR "soft tissue" OR "esthetic complications"))	518
Web of Science	TS=(("classification" OR "decision tree" OR "guideline") AND ("Dental implants" OR "peri-implant") AND ("esthetic complications" OR " soft tissue dehiscences" OR " soft tissue deficiencies" OR "mucosal marginal defects" OR "recession" OR "deficiencies" OR "defect" OR "dehiscence" OR "soft tissue" OR "esthetic complications"))	449
Cochrane library	#1 [Classification] #2 "classification" OR "decision tree" OR "guideline" #3 [Decision Trees] #4 [Dental Implants] #5 "Dental implants" OR "peri-implant" #6 "esthetic complications" OR "soft tissue deficiencies" OR "mucosal marginal defects" OR "recession" OR "deficiencies" OR "defect" OR "dehiscence" OR "soft tissue" OR "esthetic complications" #7 (#1 OR #2 OR #3) AND (#4 OR #5) AND #6	72

characteristics, critical aspects assessed by each classification, category and subcategory division of PMMD, and proposed clinical management.

Results

The initial database search yielded a total of 1,304 entries. One additional article was identified through hand searching.[19] Following the removal of duplicates, 750 entries remained, of which 742 were excluded after title and abstract screening. After a full-text review, 5 studies satisfied the eligibility criteria[13,14,17–19] and were included in the final selection. Kappa scores for interexaminer agreement for title and abstract review as well as full-text review were 0.9 and 1.0, respectively. The article selection process is depicted in Fig 1. All of the included articles addressed the topic of PMMD classification linked to clinical recommendations.[13,14,17–19] Nonetheless, two articles also addressed the peri-implant mucosal thickness deficiencies without dehiscence-type defects.[13,17]

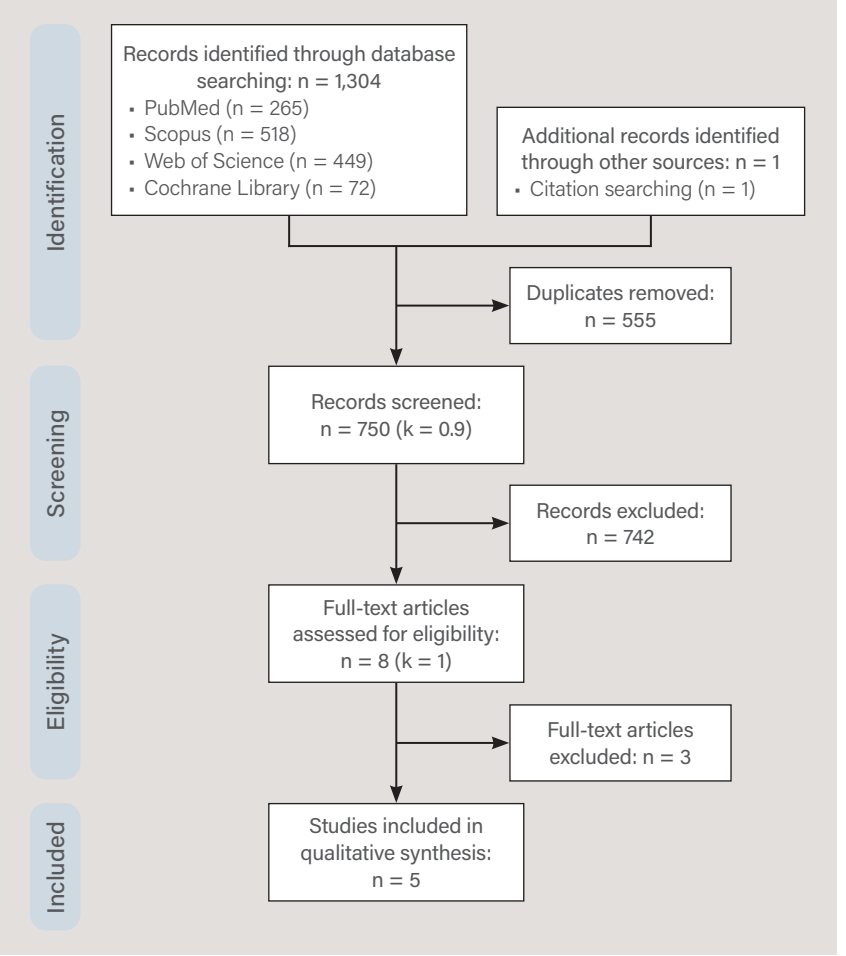
Critical Aspects Reported in the Included Studies

All of the studies evaluated the 3D implant position, postoperative ISPs, and peri-implant soft tissues. However, only two articles analyzed the peri-implant osseous component in the clinical decision-making process.[17,18] A summary of critical aspects evaluated by each classification is depicted in Table 2.

3D implant position

The 3D implant position was the first factor taken into consideration in the decision-making process in three studies.[14,17,18] Nevertheless, it should be highlighted that there was significant heterogeneity among the included investigations regarding the definition of implant malposition. Most articles defined inadequate implant position as hindering proper maintenance or optimal restoration.[14,17,19]

Gamborena and Avila-Ortiz specified that an implant should be placed at least 3 mm apical to the desired restoration margin and have a maximum angulation discrepancy of 25 degrees between the implant and prosthetic crown axes.[14] Zucchelli et al



◀ **Fig 1** PRISMA flowchart illustrating the study selection process.

Table 2 Key Factors Reported in the Literature to Establish an Appropriate Diagnosis and Treatment of PMMDs

Studies	Critical aspects
Zucchelli et al, 2019[13]	▪ Location of the mucosal margin ▪ Facial contour of the implant-supported crown ▪ Buccopalatal position of the implant platform ▪ Papilla height
Gamborena and Avila-Ortiz, 2021[14]	▪ ISPs ▪ 3D implant position ▪ Peri-implant soft tissue dehiscence ▪ Papilla height and interproximal bone level
Mesquita De Carvalho et al, 2019[17]	▪ 3D implant position ▪ Peri-implant hard tissue ▪ Peri-implant soft tissue
Alrmali et al, 2023[18]	▪ 3D implant position ▪ Peri-implant hard tissue ▪ Peri-implant soft tissue (ie, keratinized tissue, buccal soft tissue volume, and papilla height) ▪ ISPs
Suzuki et al, 2012[19]	▪ 3D implant position ▪ Peri-implant soft tissue dehiscence ▪ Papilla height

described implant mispositioning (Class IV) as the implant platform being more buccally positioned than the imaginary straight line connecting the profile of the adjacent teeth at the level of the soft tissue margin.[13] Finally, Alrmali et al recommended an initial clinical examination and a radiographic analysis, including periapical radiographs and/or a CBCT scan, to determine whether the implant position is inside or outside the alveolar contour.[18]

ISPs

All of the included studies evaluated ISPs in the clinical management of PMMD. The study by Zucchelli et al primarily focused on the ISP location. They recommended that when the crown profile is positioned more buccally than the imaginary curved line connecting the profile of adjacent teeth, the ISP should be removed prior to surgical intervention.[13] In contrast, two other classifications suggest replacing the patient's restoration with a provisional ISP that allows for contour modifications during the subsequent surgical phase.[17,19] It is noteworthy that the recommended treatments proposed by Zucchelli et al involve a combined prosthetic-surgical approach.[13] Similarly, Gamborena and Avila-Ortiz highlighted a meticulous preoperative evaluation of ISP proportions and contours.[14] Another study also recommended removing the ISP, regardless of whether surgical therapy is indicated.[18] Therefore, the included studies especially emphasize the importance of designing temporal/definitive abutments or ISPs with minimal emergence or undercontoured profiles during treatment to achieve predictable outcomes.[13,14,17–19]

Soft tissue features

Soft tissue assessment is evaluated across all of the included classifications.[13,14,17–19] Mesquita De Carvalho et al proposed a division of defects into three categories: recession, papilla defects, and volume deficiencies.[17] Similarly, Zucchelli et al evaluated buccal mucosal volume (Class I), mucosal margin (Classes II, III, and IV), and subcategories of papilla height (a, b, c).[13] Suzuki et al assessed the severity of buccal mucosal height (Classes 1, 2, and 3) and the interproximal soft tissue deficiencies (subclasses a and b).[19] The classification by Gamborena and Avila-Ortiz evaluated facial peri-implant mucosal deficiencies (Types 1, 2, and 3) and the features of unilateral (Type 2) or bilateral (Type 3) papilla with height loss.[14] Finally, Alrmali et al highlighted the evaluation of the buccal soft tissue volume and keratinized mucosa width around the implant, in conjunction with the interproximal papilla height and the clinical attachment level of the adjacent teeth.[18] The categories used in each classification are shown in Fig 2.

Hard tissue characteristics

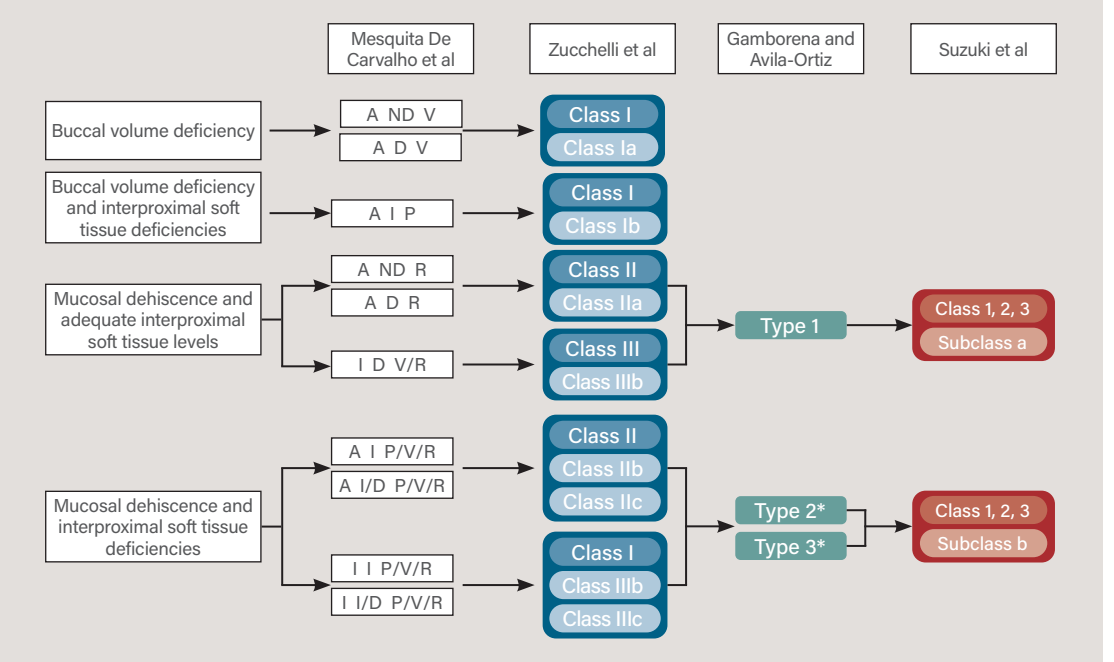
The consideration of hard tissues surrounding implants is reported in three classifications.[14,17,18] Mesquita De Carvalho et al distinguished between three clinical scenarios: no defect, dehiscence-type defect, and interproximal bone deficiencies.[17] Similarly, Alrmali et al recommend a radiographic evaluation of the buccal bone thickness and interproximal bone levels on the adjacent teeth,[18] whereas Gamborena and Avila-Ortiz[14] only addressed the interproximal bone level to decide the type of defect despite their acknowledgment that PMMDs are frequently associated with underlying buccal bone dehiscences.

Treatment Approaches

Malpositioned implant

Gamborena and Avila-Ortiz reported that unfavorable implant position should be addressed, when feasible, with replacement or modification of the prostheses to achieve satisfactory outcomes. Nevertheless, when restorability is not viable (eg, implants placed < 3 mm apical from the desired mucosal margin and with an angulation discrepancy up to 25 degrees), implant submersion or removal must be considered.[14]

Similarly, Mesquita De Carvalho et al recommended explantation or permanent submergence when the implant does not allow for the correct maintenance and/or cannot be optimally restored.[17] Zucchelli et al suggested implant explantation when: the mucosal margin is located more apical than the ideal gingival margin position of the adjacent natural tooth, the ISP profile is located outside the imaginary curve line that connects the profile of the adjacent teeth at the soft tissue margin level, and the implant head is outside the imaginary straight line connecting



▲ **Fig 2** Similarities/differences between categories of each classification. For Mesquita De Carvalho et al's classification, there are green, blue, and red letters. For green letters: A = adequate; I = inadequate. For blue and red letters: D = bone dehiscence/fenestration; I = bone interproximal defect; ND = no bone defect; P = papilla lost; R = apical migration of the mucosal margin; V = mucosal volume deficiency.
*This classification distinguishes between unilateral and bilateral papilla height loss. If the implant position is nonrestorable, it will not be considered for classification, and explantation will be indicated.

the profile of the adjacent teeth at the soft tissue margin level, al lin conjunction with the height of at least one papilla < 1 mm coronal to the ideal mucosal margin position of the ISP.[13] Suzuki et al recommended explantation when the implant position is not only nonideal but also far away from the optimal position.[19] In cases of severe buccal implant positioning and/or limited prosthetic solutions, implant submergence or removal is recommended by Alrmali et al.[18]

Buccal volume deficiency considerations

Pure buccal mucosal volume defects without soft tissue dehiscence were assessed in two studies.[13,17] Mesquita De Carvalho et al and Zucchelli et al recommended compensating for the deficiency with a soft tissue augmentation procedure by utilizing a subepithelial connective tissue graft (CTG) via a coronally advanced flap (split-full-split thickness or envelope approach).[13,17] In cases involving dehiscence bone defects, Mesquita De Carvalho et al suggested a combination of CTG with a bone augmentation procedure via guided bone regeneration.[17] When both buccal volume and papilla height deficiencies are present, Mesquita De Carvalho et al suggested orthodontic extrusion in combination with a CTG,[17] whereas Zucchelli et al advocated for a prosthetic-surgical treatment strategy.[13]

Peri-implant mucosal dehiscence

In the presence of adequate interproximal soft tissue levels

All of the classifications addressed this clinical situation and recommend a bilaminar soft tissue augmentation procedure with the use of a CTG and a coronally advanced flap via a tunnel or a split-full-split thickness approach.[13,14,17–19]

Alrmali et al evaluated the buccal mucosal volume and ISPs. When there is adequate buccal soft tissue volume (> 2 mm thick), a pure prosthetic treatment with the placement of a provisional ISP is suggested. If the tissue volume is deficient (< 2 mm), a surgical bilaminar approach with a

CTG is recommended. In cases where a combined buccal mucosal deficiency is present in conjunction with an inadequate ISP emergence profile, a surgical-prosthetic approach is suggested, with soft tissue augmentation with a CTG and the placement of a provisional ISP. Replacing the ISP with a satisfactory emergence profile is also advised in a later stage.[18]

Another described treatment approach was regarding submerged healing and the decision to either remove the ISP or to modify/replace the ISP with the use of abutments. Two studies left this aspect as optional to the clinician's evaluation.[14,17] Conversely, Zucchelli et al recommended crown removal if the crown profile is positioned buccally to the imaginary curved line connecting the profiles of adjacent teeth, while it is not necessary in other situations.[13]

Suzuki et al proposed different approaches based on the height of the buccal soft tissue dehiscence. For PMMD limited to the surface of the ISP, they recommended the use of a bilaminar approach with a CTG with/without modifications to the ISP. In cases where the PMMD extends beyond the interface between the implant platform and the restoration/abutment, a CTG was recommended. It should be highlighted that submerged healing may be indicated for tissue-level implants, while a customized provisional ISP or healing abutment should be placed for bone-level implants. Finally, in cases of exposed threads, they suggested implant surface decontamination and a CTG with or without a bone augmentation procedure via guided bone regeneration.[19]

In the presence of interproximal soft tissue deficiencies

Buccal soft tissue dehiscence with interproximal papilla involvement is a clinical scenario addressed by all of the included classifications.[13,14,17–19]

Mesquita De Carvalho et al recommend orthodontic extrusion of the adjacent teeth in combination with a CTG when interproximal soft tissue atrophy is present (with or without submerged healing). In cases where hard tissue defects are also present, an optional bone augmentation procedure could be considered.[17] Two other studies also suggested orthodontic extrusion as a treatment option, in conjunction with a prosthetic-surgical approach.[14,18] These studies proposed a soft tissue augmentation procedure with a CTG via coronally advanced flap (split-full-split thickness or envelope approach) in the crestal and buccal aspects of the implant to provide support to the papilla (ie, horizontal and vertical soft tissue augmentation). Gamborena and Avila-Ortiz[14] advocated for the use of a slim undercontoured abutment without a prosthetic connection, allowing maximum space for the CTG. In complex cases where soft tissue reconstruction is not feasible, they suggested using pink ceramic or composites in the ISP.

Taking a different perspective, Zucchelli et al considered the evaluation of the ISP profile position and papilla height and provided various decision-making processes. If the papilla is positioned between 1 and 3 mm coronal to the ideal mucosal margin position, they recommended a combined prosthetic-surgical approach. However, if the papilla is < 1 mm coronal to the ideal mucosal margin position, they suggested a CTG with submerged healing. Special attention was given by the authors when the implant platform is positioned more buccally; in such cases, they recommended a CTG with submerged healing if the papilla height is between 1 and 3 mm, while implant removal was suggested if the papilla height is < 1 mm.[13] In this sense, Alrmali et al established a 3-mm threshold for papillae height: When a papilla has a deficiency but is > 3 mm in height, only horizontal soft tissue augmentation will be needed, but when the papillae height is < 3 mm, a combined horizontal and vertical soft tissue augmentation with submerged healing is recommended.[18]

Discussion

This study was designed as a scoping review. This type of review has been defined as "a type of evidence synthesis that aims to systematically identify and map the breadth of evidence available on a particular topic, field, concept, or issue, often irrespective of source (ie, primary research, reviews, non-empirical evidence) within or across particular contexts. Scoping reviews can clarify

key concepts/definitions in the literature and identify key characteristics or factors related to a concept, including those related to methodological research."[22] Considering this definition and the limited but highly heterogeneous information available on this topic to date, as well as the characteristics of the studies, a proper quantitative analysis could not be performed. Therefore, a scoping review format was deemed suitable to meet the primary objective of compiling and critically analyzing the most relevant information in available classifications linked with treatment recommendations on the management of PMMDs at nonmolar single-implant sites; the goal was to provide an overview of recommended interdisciplinary therapy options and identify gaps of knowledge.

It is important to consider the potential biases and confounding factors observed in the studies included in this review. The first classification with clinical recommendations was published by Suzuki et al in 2012.[19] However, it lacked details on other potential factors influencing PMMDs and the proper evaluation of other components of the peri-implant phenotype. Thus, this classification did not gain popularity and acceptance in the dental community. In 2019, two different research groups led by Zucchelli et al[13] and Mesquita De Carvalho et al[17] developed new classifications on this topic. Zucchelli et al's study involved 11 clinical scenarios, including 4 classes and 3 subclasses.[13] This classification not only focused on the treatment of buccal PMMDs but also evaluated the lack of keratinized mucosal width and mucosal thickness/volume for the first time. However, some difficulty remains in the complexity of its applicability in daily clinical practice and research, such as how to discern between an adequate ISP contour and 3D implant position. Similarly, the clinical decision tree made by Mesquita De Carvalho et al presents limitations, as it focuses solely on three different pillars: the 3D implant position and the peri-implant hard and soft tissue characteristics.[17] In 2021, Gamborena and Avila-Ortiz published an elaborate classification linked to treatment alternatives exclusively in implants that were deemed restorable.[14] Most recently, Alrmali et al also proposed a new classification wherein PMMDs were described only at the facial site with/without interproximal papillary height loss.[18]

Based on the screened evidence, their heterogeneity and limitations, and considering the evaluated clinical and radiographic parameters in the included studies, the following treatment-driven recommendation based on key factors for facial PMMD at single implants in the anterior esthetic region bound by natural teeth that have not been diagnosed with peri-implantitis[23] is hereby summarized.

Treatment-Driven Recommendation

Once the comprehensive preoperative evaluation is performed and there is a clear understanding of the critical factors that are playing a role in the development of PMMD, the less invasive and most predictable approach to achieve the desired goals should be performed. To ensure optimal outcomes, a thorough evaluation of five critical domains should be used, utilizing reliable and reproducible methods:

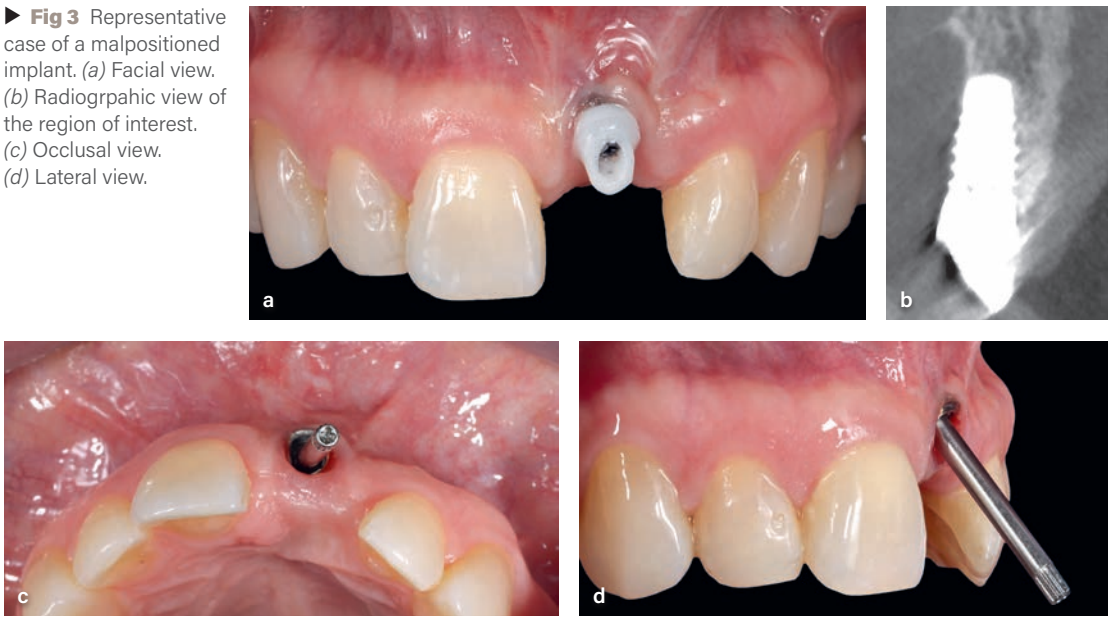
- 3D implant position
- ISP
- Peri-implant phenotype dimensions[10]
- Anatomical-related factors (ie, PMMD depth and width, the characteristics of the mesial and the distal papillae, and interproximal bone height)
- Periodontal status of the adjacent teeth (ie, mucogingival deformities and the existence of moderate to severe clinical attachment loss)

A summary of different treatment approaches according to specific clinical situations related to PMMD management is depicted in Table 3.

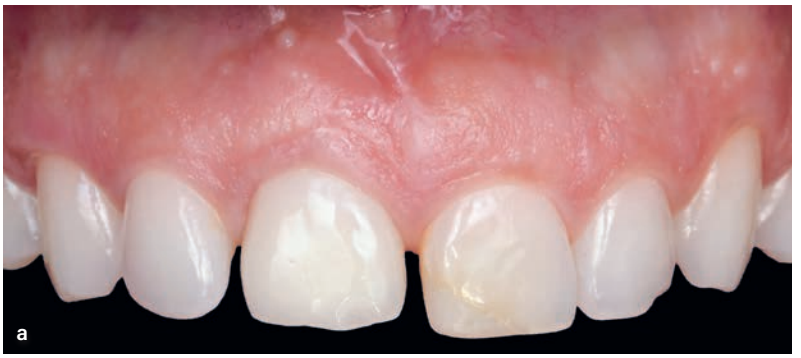
The 3D position and diameter of the implant are of great importance, as inadequate treatment planning and technical execution in surgical and prosthetic selection could be a predisposing factor for PMMD. It is therefore noteworthy that the placed implant's 3D position and type should be properly evaluated. When the implant position is deemed inadequate and a purely surgical or a combined surgical-prosthetic approach would not lead to predictable outcomes, the implant should be explanted or permanently submerged. An example of implant malposition is shown in Fig 3.

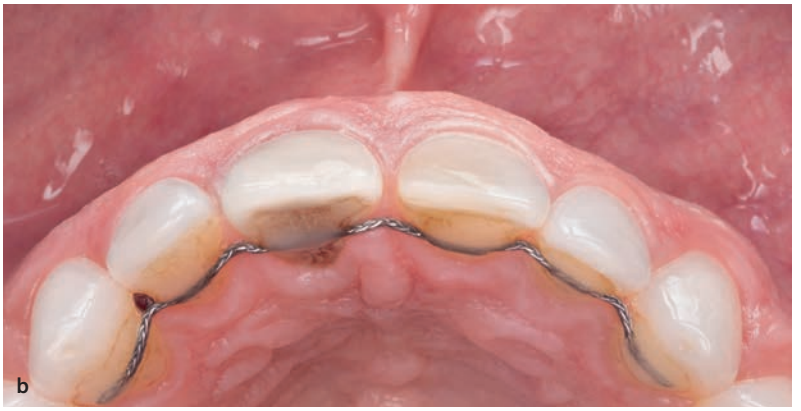
Table 3 Treatment Approaches According to Specific Clinical Situations

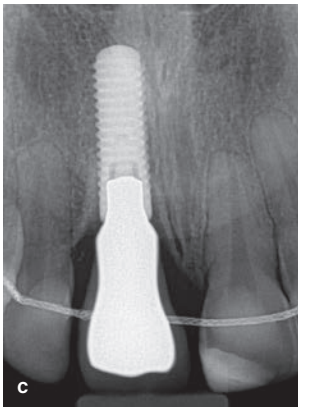
Clinical situation	Treatment approaches
Inadequate implant position	**Explantation or implant submergence:** ▪ Nonrestorable implant ▪ Platform more buccal than the virtual line between adjacent teeth ▪ Implant is placed < 3 mm apical to the desired restoration margin ▪ Angular discrepancy > 25 degrees between the implant and prosthetic crown axes *If there is an inadequate implant position but it can be restored: Prosthetic approach depending on the PMMD type defect and other related factors.
PMMD with adequate mucosal thickness/volume and interproximal soft tissue levels	**Prosthetic approach:** ▪ Slim undercontoured profile ▪ Modification of the emergence profile ▪ Definitive replacement of the ISP
PMMD with mucosal thickness/volume and adequate interproximal soft tissue levels	**Mainly surgical:** ▪ Bilaminar approach utilizing a CTG (preferably) via a coronally advanced flap **Combining surgical/prosthetic approaches:** ▪ Bilaminar approach utilizing a CTG (preferably) via a coronally advanced flap ▪ Slim undercontoured profile ▪ Modification of the emergence profile ▪ Definitive replacement of the ISP
PMMD with adequate buccal soft tissue volume in the presence of interproximal soft tissue level deficiencies	**Prosthetic approach:** ▪ Slim undercontoured profile ▪ Modification of the emergence profile **Definitive replacement of the ISP:** ▪ Forced orthodontic extrusion ▪ Guided tissue regeneration *An additional surgical intervention via a bilaminar approach utilizing a CTG (preferably) could boost the therapeutic outcomes.



▶ **Fig 3** Representative case of a malpositioned implant. *(a)* Facial view. *(b)* Radiogrpahic view of the region of interest. *(c)* Occlusal view. *(d)* Lateral view.





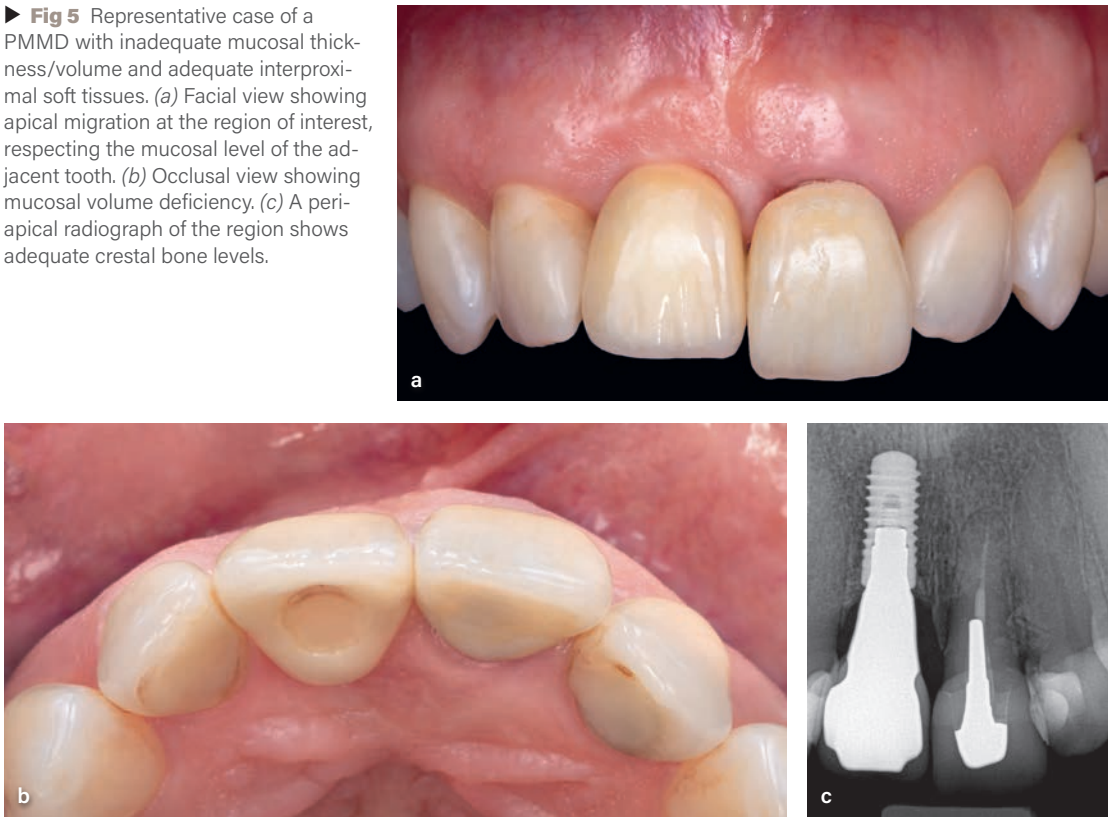


◀ **Fig 4** Representative case of a PMMD with adequate mucosal thickness/volume and interproximal soft tissues. *(a)* Facial view showing apical migration at the region of interest. *(b)* Occlusal view showing adequate mucosal volume. *(c)* A periapical radiograph of the region shows adequate crestal bone levels.

Similarly, a proper evaluation of the ISP, independent of the PMMDs, is mandatory to establish whether there is a need to adjust or completely replace the ISP to achieve satisfactory esthetic and functional outcomes in conjunction with peri-implant health. Indeed, the primary treatment for PMMD with adequate mucosal thickness/volume and interproximal soft tissue levels may solely involve a prosthetic approach, with the use of a slim undercontoured profile, or modification of the emergence profile and the definitive replacement of the ISP.[24,25] A representative case is depicted in Fig 4. As reported in a study by González-Martín et al,[25] adequate management of the implant restorations (according to the specific clinical scenario) and following the principles of critical and subcritical contours to optimize the emergence profile is mandatory for obtaining satisfactory esthetic outcomes.

In clinical scenarios where PMMD is combined with a lack of mucosal thickness/volume but in the presence of adequate interproximal soft tissue levels, the treatment decision will hinge upon a bilaminar soft tissue augmentation procedure, preferably with the use of CTG from the posterior palate or maxillary tuberosity[26] or a substitute biomaterial[27] (ie, in cases where autogenous soft tissue grafts are contraindicated) via a tunnel or split-full-thickness coronally advanced flap.[28] This type of clinical scenario may include a purely surgical or a combined surgical-prosthetic approach, depending on the ISP characteristics, applying the prosthetic management described above. In many situations, a combined approach involving the modification of the emergence profile, or replacement with a healing abutment, is indicated to achieve predictable outcomes. Most of the classifications advocate reserving submerged healing for severe mucosal dehiscence defects, suggesting that most of those clinical scenarios without papilla involvement can be successfully addressed without submerged implant healing. An example of this case scenario is shown in Fig 5.

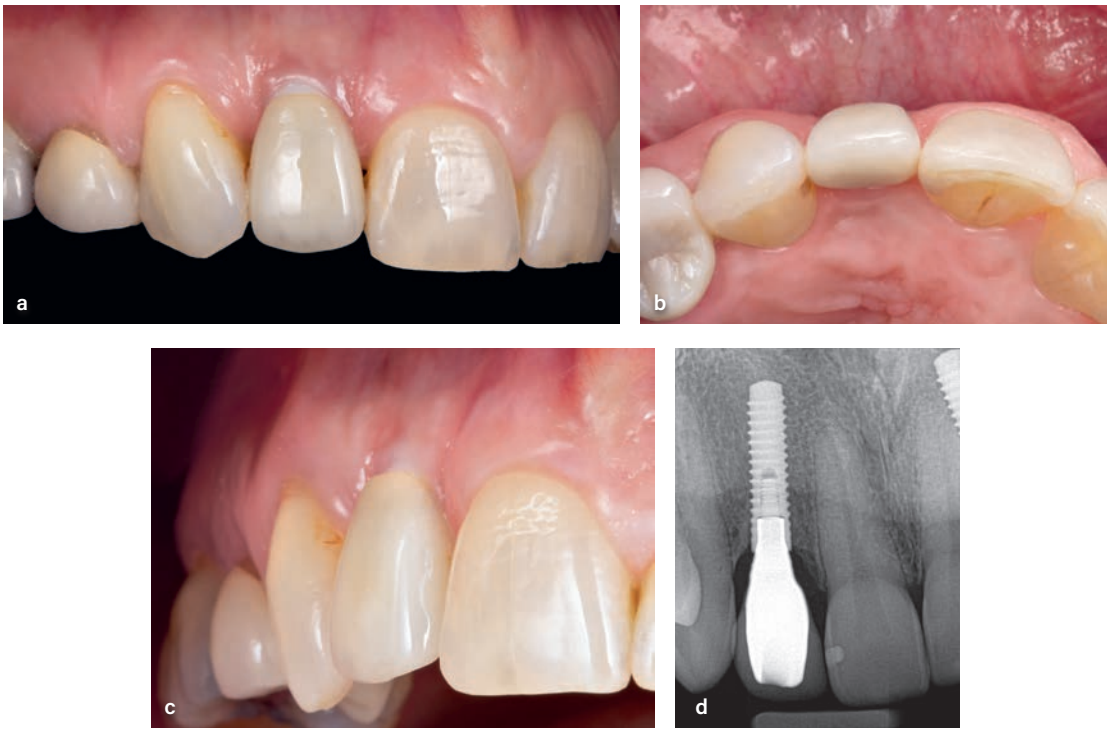
Clinicians should also be aware that the need for a minimum bone thickness around an implant, to achieve good peri-implant tissue stability, esthetics, and health, is still under debate and lacking a consensus. An adequate preoperative evaluation



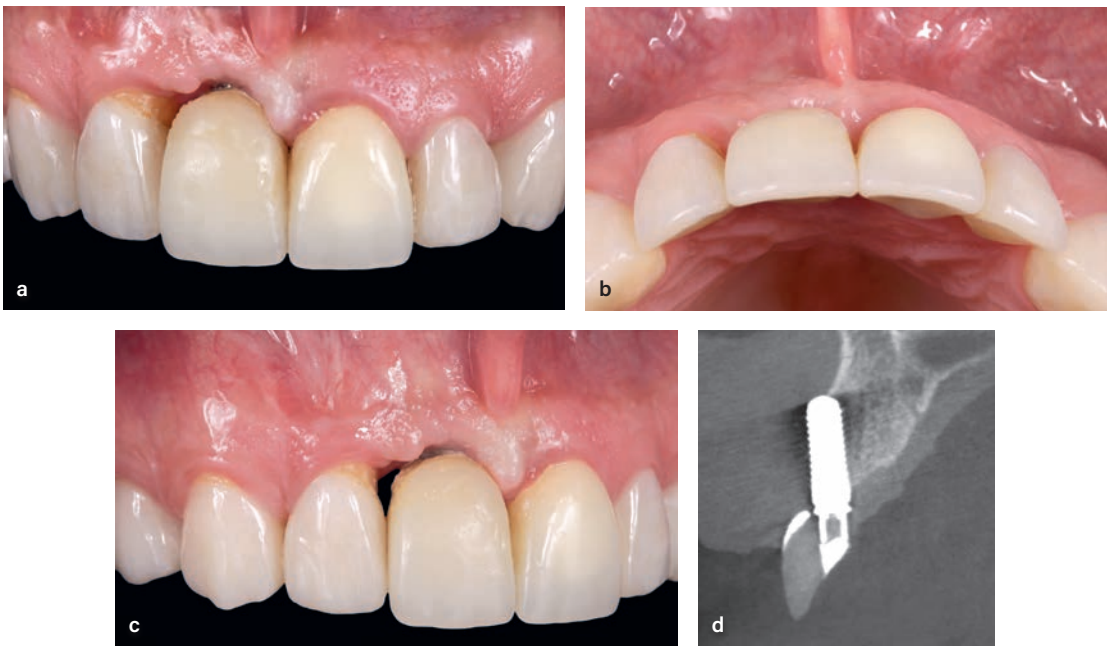
▶ **Fig 5** Representative case of a PMMD with inadequate mucosal thickness/volume and adequate interproximal soft tissues. *(a)* Facial view showing apical migration at the region of interest, respecting the mucosal level of the adjacent tooth. *(b)* Occlusal view showing mucosal volume deficiency. *(c)* A periapical radiograph of the region shows adequate crestal bone levels.

of this aspect is recommendable, even if no bone reconstruction procedures are performed.[10,29,30] However, the use of bone augmentation procedures for treating buccal bone dehiscences in loaded implants is questionable and is not the primary recommended approach for the treatment of PMMD.[31]

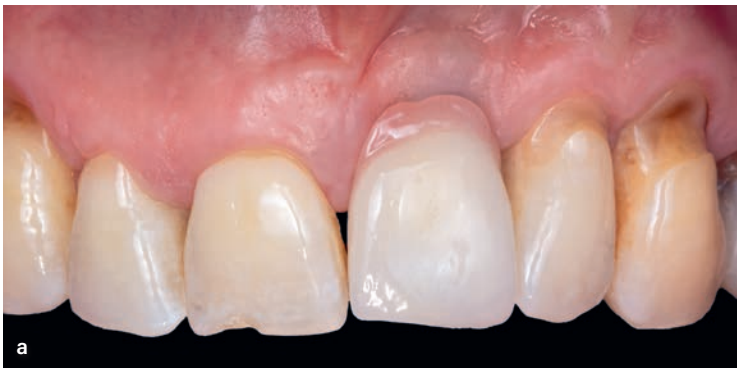
When facing interproximal papillary height loss, the clinical situation becomes more challenging. Evaluating the periodontal status of the adjacent teeth (ie, the existence of moderate to severe clinical attachment loss, mucogingival deformities, and bone levels) is crucial to achieving successful outcomes. Furthermore, the option of guided tissue regeneration and/or forced orthodontic extrusion[32] should be considered as a potential treatment approach, particularly in specific clinical scenarios where it offers a viable solution for restoring interproximal hard/soft tissue height and enhancing esthetics. Nonetheless, orthodontic therapy should be performed, if possible, after the maturation of the soft tissue augmentation procedures, not before.[32] However, if orthodontic extrusion is considered unsuitable, a surgical-prosthetic approach with/without periodontal therapy is then recommended. Treatments involving papillae atrophy generally involve the use of a provisional abutment or crown with a slim emergence contour, providing sufficient space for the interproximal soft tissues,[24,25] in conjunction with at least one surgical intervention to achieve horizontal and sometimes vertical augmentation of the soft tissue. However, in challenging situations, due to their demanding nature, a submerged healing approach should be considered. Moreover, when the papilla height measures < 3 mm, submerged healing should always be the approach of choice to enhance the overall treatment success. Representative cases of this specific case scenario are depicted in Figs 6 and 7. When buccal or interproximal soft tissue levels cannot be reconstructed with surgical and orthodontic therapy, the use of pink composite or ceramic with an adequate design to allow cleansability is suggested. An example of the use of pink ceramic with an inadequate

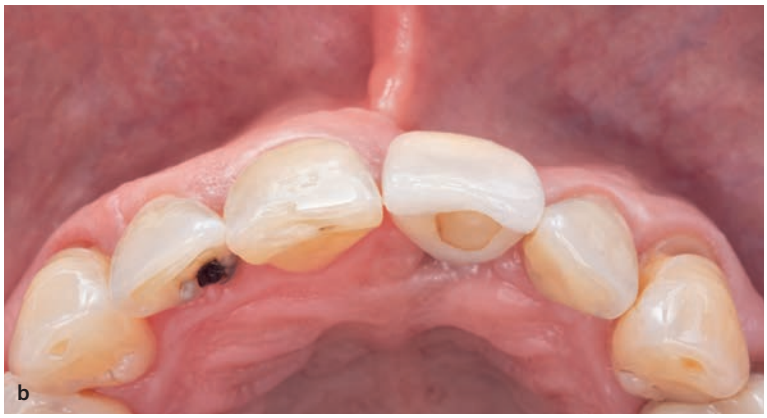


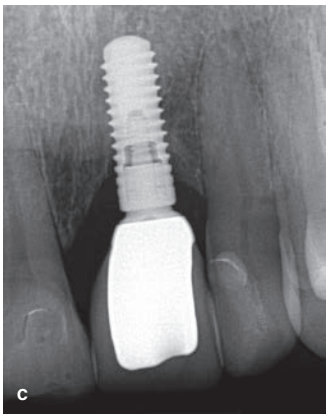
▲ **Fig 6** Representative case of a PMMD with inadequate mucosal thickness/volume and slight interproximal soft tissue deficiencies. *(a)* Facial view showing apical migration of the mucosal margin at site 12, with respect to that of the adjacent teeth, and revealing exposure of the transmucosal prosthetic component with interproximal soft tissue deficiencies. *(b and c)* Occlusal and lateral views, respectively, showing mucosal volume deficiency. *(d)* A periapical radiograph of the region shows adequate crestal bone levels.



▲ **Fig 7** Representative case of a PMMD with inadequate mucosal thickness/volume and severe interproximal soft tissue deficiencies in combination with a malpositioned implant. *(a)* Facial view showing apical migration of the mucosal margin at site 11, with respect to that of the adjacent tooth, with a pronounced interproximal soft tissue deficiency. *(b and c)* Occlusal and lateral views, respectively, showing mucosal volume deficiency and pronounced interproximal soft tissue deficiency. *(d)* A radiograph of the region shows inadequate 3D implant positioning.







▶ **Fig 8** Representative case of a PMMD with inadequate mucosal thickness and interproximal soft tissue deficiencies. Note the inadequate restoration design with pink ceramic to allow cleansability and the subsequent marginal bone levels. *(a)* Facial view showing apical migration of the mucosal margin at site 21, with respect to that of the adjacent tooth 11. *(b)* Occlusal view showing mucosal volume deficiency. *(c)* A radiograph of site 21 shows the crestal bone loss.

design is depicted in Fig 8. Nonetheless, depending on the clinical situation, restorative work on adjacent teeth should be considered to achieve optimal therapeutic outcomes.

Limitations

There are several limitations in the current scoping review. First, the included studies primarily propose classifications and clinical recommendations but lack validation through well-conducted clinical trials. Therefore, all of the included classifications were not proven to be realizable and consequently applicable and reproducible in clinical and research settings. Nonetheless, although the included studies based the clinical recommendations on expert opinions, all of them provided a clinical decision-making guide substantiated by clinical experience and, when possible, based on relevant evidence. Second, there were a limited number of articles meeting the inclusion criteria, and they were heterogeneous in terms of relevant considerations and therapeutic options. Third, there was limited information regarding other systemic and local factors that could influence the outcomes of therapy, such as smoking, diabetes, and self-performed oral hygiene measures. It is also noteworthy that only implants placed in nonmolar sites with the presence of adjacent teeth, without a diagnosis of peri-implantitis, involving PMMDs were included. Scenarios involving peri-implantitis would require other interventions. Therefore, future well-conducted clinical trials utilizing standardized definitions and reproducible parameters[33–36] should focus on evaluating the effect of surgical (ie, treatment approach, use of soft tissue graft or substitute) and prosthetic (ie, management of the emergence profile, ISP removal) approaches based on local (ie, PMMD characteristics, implant position and features, peri-implant phenotype) and systemic factors (ie, smoking, diabetes), as well as patient-reported outcomes (ie, discomfort, pain, satisfaction with the treatment and esthetics). Finally, further studies should also evaluate the realizability of the proposed classifications and their recommended clinical decision-making process on the outcomes of therapy.

Conclusions

In recent years, there has been an increase in treatment-oriented classifications for the management of PMMD. To ensure successful interdisciplinary PMMD treatment, an adequate presurgical assessment of the site is crucial. The clinical decision-making process should be based on various factors such as 3D implant position, restorability of the ISP, characteristics of the peri-implant phenotype, anatomical-related factors, and periodontal status of the adjacent teeth.

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Adrià Jorba-Garcia, DDS, MS, PhD
Department of Oral Surgery and Implantology, School of Medicine and Health Sciences, University of Barcelona, Barcelona, Spain; IDIBELL Institute, Barcelona, Spain.

Oscar Gonzalez-Martin, DDS, MSc, PhD
Department of Periodontology, Complutense University of Madrid, Madrid, Spain; Department of Restorative Dentistry and Biomaterials Sciences, Harvard School of Dental Medicine, Boston, Massachusetts, USA; Private practice, Madrid, Spain.

Leandro Chambrone, DDS, MSc, PhD
Evidence-Based Hub, Interdisciplinary Research Center Egas Moniz (CiiEM), Egas Moniz-Cooperative of Higher Education, Caparica, Almada, Portugal; Unit of Basic Oral Investigation (UIBO), School of Dentistry, Universidad El Bosque, Bogotá, Colombia.

Manrique Fonseca, Dr med dent, MAS
Department of Reconstructive Dentistry and Gerodontology, University of Bern School of Dental Medicine, Bern, Switzerland.

Emilio Couso-Queiruga, Dr med dent, DDS, MS
Department of Oral Surgery and Stomatology, University of Bern School of Dental Medicine, Bern, Switzerland.

Correspondence to:
Dr Adrià Jorba-Garcia, a.jorba@ub.edu