REVIEW ARTICLE

CONTENTS

An overview of peri-implant soft tissues dehiscence (PSTD): A narrative review

Ali Jasim Mohammed[1], Ahmad Fakrurrozi Mohamad[1], Muhammad Annurdin Sabarudin[2], Husniyati Roslan[1]
[1]DEPARTMENT OF DENTAL SCIENCE, ADVANCED MEDICAL & DENTAL INSTITUTE, UNIVERSITI SAINS MALAYSIA, PULAU PINANG, MALAYSIA
[2]DEPARTMENT OF PERIODONTOLOGY AND COMMUNITY ORAL HEALTH, FACULTY OF DENTISTRY, UNIVERSITI SAINS ISLAM MALAYSIA (USIM), MALAYSIA

ABSTRACT

Aim: This review is designed to synthesize current evidence to magnify understanding and management of Peri-Implant Soft Tissue Dehiscence (PSTD) in implant dentistry.

Materials and Methods: A structured narrative review was conducted by systematically searching Scopus, PubMed, Web of Science, and Google Scholar for literature published between 2000 and 2025. Related studies were identified using keywords related to PSTD, with emphasis on etiology, clinical presentation, assessment method classification, and treatment approaches.

Conclusions: The review identified various etiological factors contributing to PSTD, including thin keratinized mucosa, poor oral hygiene, and improper implant positioning. The clinical features of PSTD primarily include recession of peri-implant keratinized tissue and mucosal margin with exposure of implant components, negatively affecting aesthetic and potentially leading to peri-implant disease. Accordingly, a range of assessment methods was outlined in the literature, including clinical indices, photographic analysis, and advanced imaging techniques. Notably, current studies emphasize the use of a classification system that considers tissue thickness, recession depth, and tissue quality. Several surgical and non-surgical techniques were also discussed, with soft-tissue grafting emerging as the most effective intervention for correcting PSTD.

In implant dentistry, peri-implant soft-tissue dehiscence poses serious biological and aesthetic challenges. Successful care depends on a precise diagnosis made using clinical and imaging techniques, as well as on preventive measures and soft-tissue augmentation. Although connective tissue grafting remains the most predictable strategy, further research is needed to refine categorization schemes and develop less invasive methods to improve patient outcomes and long-term stability.

KEYWORDS: PSTDs, classification of PSTD, peri-implantitis, peri-implant mucositis, implant dentistry

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INTRODUCTION

Peri-implant soft tissue is essential for the esthetic and functional purposes of supported restorations and for long-term implant survival. Peri-Implant Soft Tissue Dehiscence (PSTD), caused by insufficient keratinized tissue, can compromise implant success and negatively affect patient satisfaction. This narrative review briefly discusses PSTD and the assessment methods available in the literature, based on the current PSTD classification. PSTD is defined as insufficient coverage or recession of the soft tissue surrounding dental implants [1]. In contrast to the teeth, gingival recession is an apical shift of the gingival margin below the cementoenamel junction [2]. However, dental implants lack a standard reference level for a "normal" midfacial mucosa since clinicians disagree on its definition. Some clinicians use the mucosal margin as a reference point at the time of final restoration or exposure of the metallic implant or abutment grey surface [3]. These reference points may be inappropriate since they do not consider the gingival margin of the homologous adjacent or contralateral natural teeth. This could result in an excessively long implant superstructure, with disharmony between the marginal soft-tissue scallop and the adjacent teeth. Accordingly, most clinicians, in agreement with a consensus, agree that the peri-mucosal margin of the implant should be referenced to adjacent or contralateral sound natural teeth [4-5]. Thus, a classification for PSTD was developed to ease clinicians' diagnosis and treatment [1]. This PSTD condition can lead to poor esthetic results, increased susceptibility to infection, and poor health of the area surrounding the implant. For example, unique patient characteristics, implant design, and surgical techniques can all contribute to a lack of soft tissue

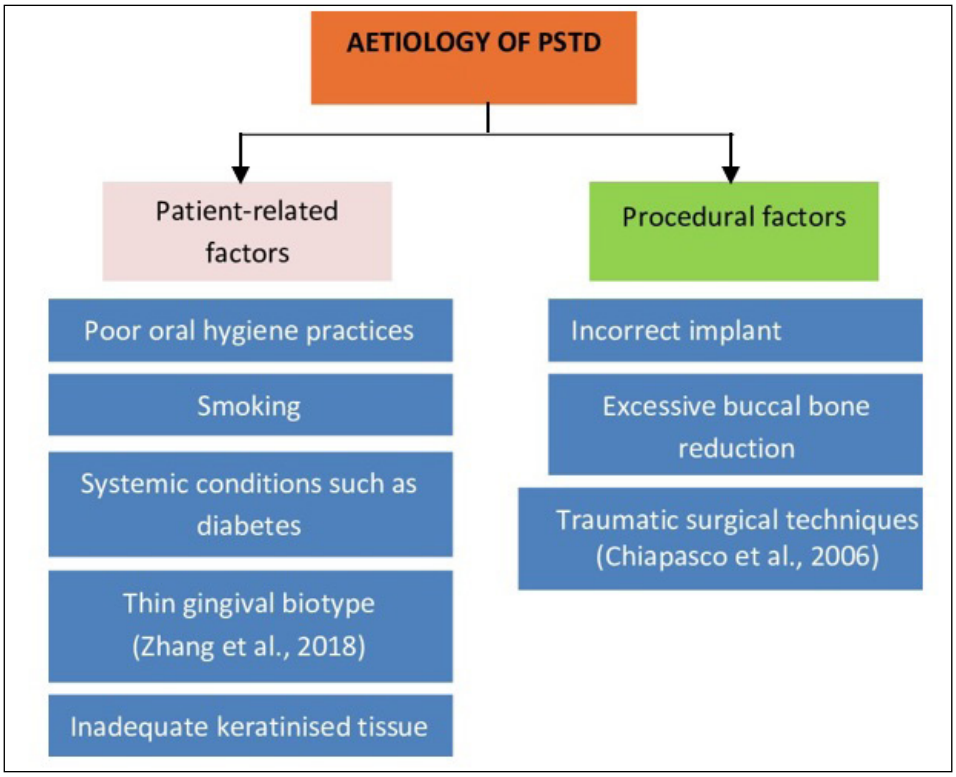


Fig. 1. The etiology of PSTDs
Source: Own materials

surrounding the implant [6]. Hence, this comprehensive review aims to critically evaluate the existing literature on the causes and risk factors of PSTD, clinical manifestations of PSTD, assessment methods, and treatment of PSTD. Additionally, this review highlights the potential implications for clinical practice. At the same time, it provides insights into future research directions, with the ultimate goal of enhancing treatment protocols for PSTD and promoting the long-term success of dental implant therapy.

AIM

This review is designed to synthesize current evidence to magnify understanding and management of Peri-Implant Soft Tissue Dehiscence (PSTD) in implant dentistry

MATERIALS AND METHODS

This narrative review was conducted to gather, analyse, and synthesize current evidence related to PSTD. The focus was on the etiology, clinical manifestations, assessment techniques, classification, and treatment modalities of PSTD. A structured approach was employed to identify and select relevant literature, providing a comprehensive overview of the topic. Accordingly, an extensive electronic search was conducted across databases, including PubMed, Scopus, Web of Science, and Google Scholar. The search included publications from January 2000 to 2025. The keywords used in the search strategy included "Peri-implant soft tissue dehiscence," "PSTD," "Peri-implant mucosa," "keratinised tissue," "implant esthetics," "Peri-implantitis," and "soft tissue grafting." Boolean operators such as AND & OR were applied to refine the search results. This comprehensive approach integrated current knowledge and clinical insights to enhance understanding and management of PSTD in implant therapy.

All figures is based on the authors' review, and the clinical pictures are from the authors' patients who have consented to be published in the journal.

REVIEW AND DISCUSSION

ETIOLOGY AND RISK FACTORS OF PSTD

The etiology of PSTD is multifactorial, encompassing both patient-related and procedural factors in Figure 1. Patient-related factors include insufficient soft-tissue volume, poor oral hygiene, a history of periodontitis, smoking, systemic conditions, and inadequate keratinized tissue width [7-9]. A thin or inadequate band of keratinized tissue surrounding an implant has been identified as a key risk factor for PSTD [10]. Keratinized tissue provides a protective barrier, and its absence can lead to recession and exposure of the implant surface. Clinical studies suggest that patients with less than 2 mm of keratinized tissue are more prone to peri-implant tissue complications [11]. A meta-analysis revealed that implants with less than 2 mm of keratinized mucosa



Fig. 2. The PSTD on the implant at the lower left premolar region
Source: Own materials

have significantly higher rates of plaque accumulation, inflammation, and recession compared to those with adequate keratinized tissue [12]. Plaque accumulation due to poor oral hygiene is a critical factor in the development of peri-implant diseases, including soft tissue dehiscence. Therefore, Supportive Peri-Implant Care (SPIC) following implant therapy is crucial to maintaining peri-implant health. Plaque-biofilm-induced peri-implant mucositis, if untreated, may progress to peri-implantitis and result in breakdown of both soft and hard tissues. Lang et al. (2012) conducted a long-term study demonstrating that inadequate plaque control significantly increases the risk of peri-implant soft tissue recession [13]. On the other hand, patients with a history of periodontitis are at higher risk of developing PSTD due to their compromised periodontal tissue phenotype [14]. A study [15] reported that individuals with a history of periodontitis had a higher incidence of implant complications, including increased soft tissue recession and marginal bone loss [16].

Smoking is a well-established risk factor for impaired wound healing and peri-implant complications [17]. Nicotine reduces blood flow to tissues, compromising the regenerative capacity of soft tissues and increasing the incidence of PSTD [18-19]. A systematic review by [20] reported that smokers are at a significantly higher risk of peri-implant tissue complications, including PSTD, due to impaired healing and reduced immune response. Systemic conditions, such as uncontrolled diabetes, autoimmune diseases, stress, or immunosuppressive therapies, can adversely affect wound healing and tissue health, thereby increasing the risk of PSTD [21-24]. In particular, uncontrolled diabetes has been linked to impaired collagen synthesis and a reduced inflammatory response, which may delay healing and increase susceptibility to infections [25]. A study discovered that patients with uncontrolled diabetes had higher rates of implant complications, including soft tissue dehiscence [26]. Procedural factors include incorrect implant positioning, excessive buccal bone reduction, and traumatic surgical techniques [27-28]. The positioning of dental implants plays a critical role in their success, both structurally and aesthetically. Incorrect implant positioning has been identified as a key factor contributing to PSTD, leading to aesthetic and functional complications [10]. Implant placement too close to the buccal bone plate often leads to insufficient bone volume to support the implant and adjacent soft tissue [29]. This can result in bone resorption, especially around the thin buccal bone, increasing the risk of soft tissue recession and dehiscence. Studies have demonstrated that implants placed with inadequate buccal bone thickness (< 2 mm) are prone to bone loss and mucosal recession [29-30]. A systematic review underscored that the proximity of implants to the buccal bone significantly influences long-term bone stability and soft-tissue health [31]. The study concluded that at least 2 mm of buccal bone is required to maintain peri-implant soft-tissue integrity [23, 32]. Placing an implant too superficially, with insufficient bone anchorage, can lead to instability and micromovements during the healing phase [33]. A study by Esposito et al. (1998) [34] highlighted that micromotion during healing is directly correlated with higher rates of implant failure and complications, including PSTD. Moreover, if an implant is placed too deeply subcrestally, it may also

lead to PSTD. Excessive bone remodelling can occur as the body attempts to adapt to a deeper implant, potentially leading to marginal bone loss and peri-implantitis [35]. A clinical study [36] determined that implants placed too deeply are prone to excessive crestal bone resorption, which can contribute to peri-implant tissue complications, such as PSTD, due to increased difficulty in maintaining peri-implant tissue health. Hence, proper implant depth is crucial for balancing these risks, as it provides sufficient stability for osseointegration without inducing excessive bone remodelling or soft-tissue recession in Figure 2.

Incorrect angulation of the implant can lead to biomechanical complications by causing uneven stress distribution in the surrounding bone and soft tissues [37-38]. When an implant is angled incorrectly, the forces generated during mastication are not evenly distributed, leading to increased pressure in some areas that can cause bone resorption and recession [39]. A study [40] demonstrated that improper angulation of dental implants can lead to marginal bone loss and gingival recession. The study emphasized the importance of proper angulation to ensure even force distribution and promote long-term implant success. Implants placed in areas with a thin or compromised buccal plate indicated higher rates of PSTD due to increased bone resorption over time. Therefore, preservation of the buccal plate is essential during implant placement to prevent peri-implant soft tissue complications. Guided bone regeneration may be required prior to implant placement to preserve the buccal bone plate. Crestal ridge width changes following implant placement, with or without soft-tissue augmentation, were evaluated after a 6-month healing period, with a reduction in width observed without augmentation [41]. Bone necrosis caused by excessive heat generation during implant site preparation is a significant contributor to implant failure and PSTD. When high-speed drills are used without adequate cooling, depending on the total time of exposure of bone tissue to heat, reported temperatures ranging from 47°C to 70°C could lead to thermal damage to the bone, compromising its ability to heal and integrate with the implant [42]. On the other hand, a study [43] established that thermal injury to bone significantly impairs osseointegration and increases the likelihood of complications such as bone resorption and soft-tissue recession. Thus, adequate cooling during drilling is crucial to prevent thermal damage and promote healthy peri-implant tissue healing [44]. Excessive or aggressive handling of the soft-tissue flap during surgery can damage the blood vessels supplying the surgical site, compromising the blood flow essential to healing. Moreover, trauma to the soft tissue during flap elevation can impair healing, leading to ischemia and increasing the risk of dehiscence [45]. A clinical study [46] highlighted that careful, non-traumatic handling of soft tissues during surgery is crucial for maintaining an adequate blood supply, which is essential for healing and minimizing the risk of soft-tissue dehiscence around implants. Therefore, understanding and addressing these procedural factors is critical for minimizing the risk of PSTD and promoting long-term implant success. Clinical studies have consistently demonstrated the importance of proper implant positioning, maintaining adequate buccal bone, and utilizing careful surgical techniques to preserve soft tissue and bone stability.

CLINICAL MANIFESTATIONS OF PSTDS

Soft-tissue recession exposes the implant fixture or its abutment, an essential clinical sign of PSTD. This exposure compromises aesthetics and increases the risk of plaque accumulation around the exposed areas, further contributing to peri-implant inflammation. A study [47] emphasized that implant surface exposure is often associated with a higher susceptibility to plaque accumulation, which can exacerbate the risk of peri-implant disease, particularly in cases with deficient keratinized tissue. Increased probing depths are another significant indicator of PSTD, often associated with peri-implant disease progression. Probing depths greater than 4 mm are commonly observed in cases of inflammation and soft-tissue breakdown. Studies suggest that deeper pocket depths around dental implants may indicate ongoing peri-implant tissue destruction, which can lead to further complications. According to [48], the presence of increased pocket depth, in combination with other clinical signs such as Bleeding On Probing (BOP), is strongly associated with peri-implantitis and soft tissue dehiscence. Regular monitoring of probing depths is therefore essential to prevent the progression of PSTD to more severe conditions. BOP is a hallmark of peri-implant soft tissue inflammation, indicating the presence of inflammation and compromised tissue health. When probing around an implant reveals bleeding, it is a strong indication of mucosal inflammation, which may precede bone loss in peri-implantitis. BOP is considered a reliable diagnostic tool for early detection of peri-implant mucositis [49]. In combination with other signs such as deep probing depths and implant exposure, BOP highlights the need for early intervention to prevent the progression of peri-implant disease.

ASSESSMENT METHODS OF PSTDS AND

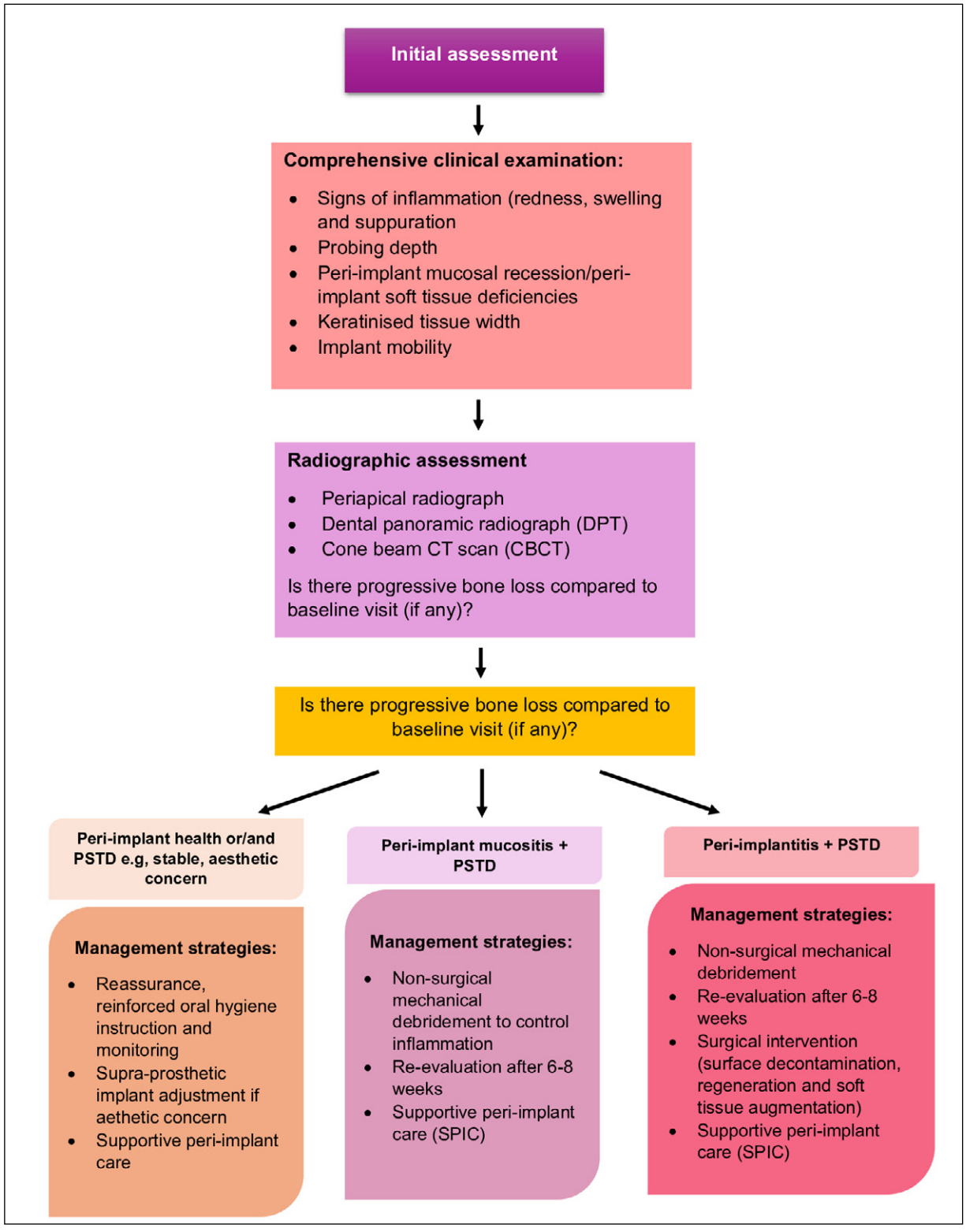


Fig. 3. Flowchart of Assessment of PSTD
Source: Own materials

THEIR CLASSIFICATION

Matthes et al. [50] and Soares et al. [51] suggested that a comprehensive assessment of peri-implant soft tissues includes clinical signs, such as BOP and probing depth measurements, as well as radiographic evaluations. Radiographs, including Cone Beam Computed Tomography (CBCT) or periapical images, provide essential information about the bone levels around the implant, allowing clinicians to detect early bone loss indicative of peri-implantitis. This assessment is crucial for distin-

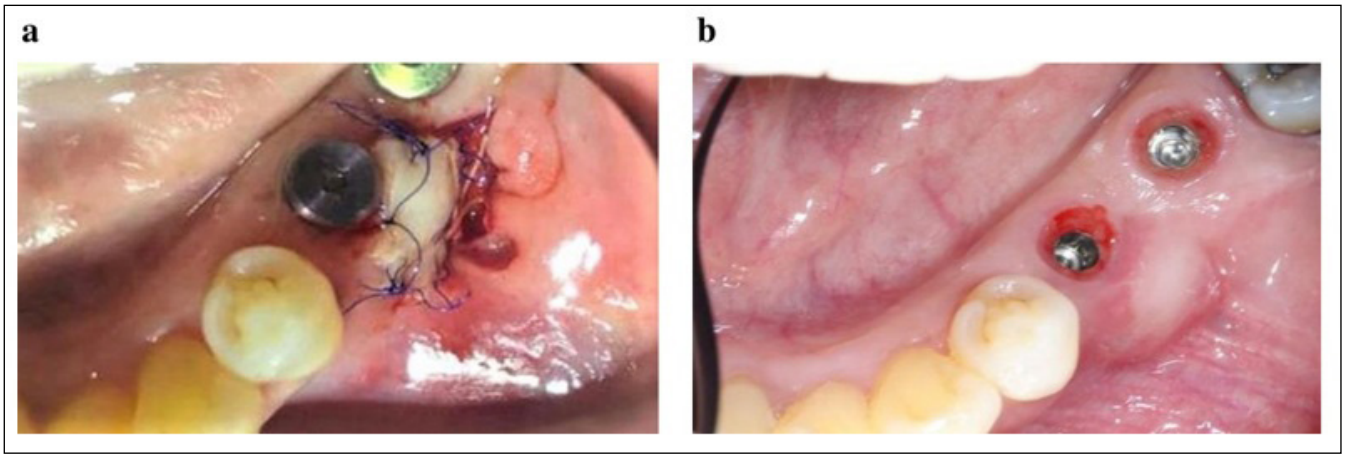


Fig. 4. Clinical management of inadequate keratinized tissue width. (a) A free gingival graft was placed on the buccal aspect of implant 34 (the lower left second premolar). (b) Increased keratinized tissue width at 3 months post-operatively.
Source: Own materials

guishing between mucositis and peri-implantitis, as the latter requires more aggressive management to prevent further bone loss and implant failure.

Furtsev et al. [52] highlighted the role of radiographic imaging in evaluating peri-implantitis, emphasizing that the presence of bone loss and increased pocket depths, in conjunction with soft tissue recession, can signal advanced peri-implant disease. Once peri-implantitis is established, the prognosis becomes more complex, as bone loss around the implant makes it increasingly difficult to manage without surgical intervention. Accurate assessment of PSTD is crucial for diagnosing the condition, planning treatment, and monitoring therapeutic outcomes. A variety of methods are commonly used to assess PSTD, ranging from clinical examinations to advanced imaging techniques in Figure 3. A comprehensive assessment of PSTD integrates clinical examination with radiographic imaging, ensuring that all aspects of soft-tissue health and implant stability are evaluated. This multifaceted approach enables early detection, accurate diagnosis, and informed treatment planning, all of which are crucial to the long-term success of dental implants. Visual inspection is the first step in diagnosing PSTD, focusing on soft-tissue changes around the implant. Clinicians assess for visible signs of soft-tissue recession, which may expose the implant or abutment surface. In addition to recession, signs of inflammation, such as erythema (redness) or edema (swelling), indicate early peri-implantitis, a precursor to peri-implant disease. Visual inspection is critical for identifying aesthetic issues and potential complications that may require further intervention. Probing depth measurements involve the use of a periodontal probe to assess the depth of the peri-implant sulcus. Increased probing depths, particularly those exceeding 5 mm, are indicative of peri-implant disease and potential bone loss. Notably, these deeper pockets may signal a breakdown in the tissue attachment and are often associated with peri-implantitis. According to [13], probing around implants is a key diagnostic tool for assessing peri-implant tissue health, and greater pocket depths often correlate with more severe soft-tissue and bone complications. The presence of bleeding upon gentle probing is a reliable indicator of soft tissue inflammation, signalling active peri-implant disease. BOP suggests that the tissues are inflamed, which is commonly associated with peri-implant mucositis, the precursor to peri-implantitis. BOP is a simple yet effective clinical tool for monitoring peri-implant health and detecting early disease activity. Renvert et al. (2018) [49] demonstrated a strong correlation between BOP and peri-implant disease progression, recommending its routine use during the implant maintenance program. Periapical radiographs are a localized imaging modality that provides detailed views of the bone levels around the dental implant. They are beneficial for detecting early bone loss, implant positioning, and any signs of peri-implantitis. However, while they provide limited information on soft tissues, periapical radiographs are a key tool for monitoring bone stability and ensuring the implant is well integrated with the surrounding structures. CBCT is considered the gold standard for assessing the three-dimensional structure of the peri-implant region. It provides highly detailed 3D images that enable precise evaluation of bone volume, implant positioning, and proximity to vital anatomical structures, such as nerves or sinuses. CBCT is particularly valuable in complex cases requiring bone grafting, sinus lifts, or implant revisions. Nack et al. (2016) [53] established the efficacy of CBCT in providing comprehensive data that enhances the accuracy of diagnosis and treatment planning, particularly in detecting early-stage peri-im-

plant bone loss. As recommended in the 2017 World Workshop Consensus Report on Peri-implant Diseases, baseline radiographic images and probing depth measurements should be taken immediately after implant placement to monitor future changes effectively [48].

MANAGEMENT AND PREVENTION OF PSTD

Prevention of PSTD begins with meticulous treatment planning and patient selection. Preventive measures are essential to minimize the risk of soft-tissue dehiscence around implants. Proper implant positioning plays a crucial role in minimizing the risk of PSTD. Implants should be placed with sufficient distance from the buccal plate and adjacent teeth, and with a minimum of 2 mm of keratinized mucosa surrounding the implant. Furthermore, studies have demonstrated that implants placed too close to the buccal bone or without adequate keratinized tissue are at higher risk of soft-tissue complications [31]. The use of guided surgery and careful surgical techniques can help ensure accurate implant placement. Soft-tissue preservation during implant surgery is critical to preventing PSTD. Minimally invasive techniques, such as flapless surgery or small flap designs, reduce trauma to the soft tissues and lower the risk of recession [54]. Preserving the integrity of the keratinized tissue surrounding the implant is also crucial for maintaining long-term peri-implant health in Figure 4. Patients should be educated about the importance of maintaining good oral hygiene around implants, as poor hygiene can contribute to peri-implantitis and subsequent soft-tissue dehiscence. Regular professional cleanings and assessments are essential for preventing plaque accumulation and monitoring for early signs of PSTD.

LIMITATIONS

Due to its narrative character and lack of adherence to a systematic review process, this review is susceptible to selection bias. Only English-language research was included in the evidence, potentially omitting relevant findings from studies published in other languages. Furthermore, direct comparisons of outcomes are hampered by the diverse study methods, sample sizes, and outcome measures across the examined publications. For the evaluation and treatment of PSTD, more robust evidence and standardized guidelines are required from future systematic reviews and meta-analyses.

CONCLUSIONS

PSTD presents significant challenges in dental implantology, necessitating prompt and accurate assessment for effective management. Advances in diagnostic imaging have enhanced the ability to evaluate and treat PSTD, contributing to better patient outcomes. Therefore, continued research and clinical innovation are essential for refining assessment methods and therapeutic approaches, ultimately improving the prognosis for patients with PSTD. To reduce the risk of PSTD, this review emphasizes the importance of sufficient keratinized tissue, appropriate implant location, and careful surgical technique. Clinical signs such as peri-implant inflammation, implant surface exposure, and mucosal recession emphasize the importance of prompt and precise evaluation. Clinicians can now more accurately identify and categorize PSTD using modern diagnostic techniques, such as probing and photographic recording, as well as sophisticated imaging modalities, such as CBCT. Soft tissue augmentation techniques, particularly connective tissue grafting, continue to provide the most consistent results in treating PSTD from a therapeutic standpoint. However, the variation in long-term stability underscores the need for further comparative research and standardized protocols. Preventive measures remain crucial for maintaining the health and aesthetics of the peri-implant area, particularly through patient education and strict maintenance regimens. In response, future studies should focus on improving PSTD classifications, validating novel evaluation instruments, and investigating minimally invasive regenerative methods to improve functional and aesthetic outcomes. As such, to create evidence-based recommendations that ensure the long-term viability of implant therapy, interdisciplinary collaboration among periodontists, prosthodontists, and oral surgeons will be essential.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

CORRESPONDING AUTHOR
Ahmad Fakrurrozi Mohamad
Department of Dental Science,
Advanced Medical & Dental Institute,
Universiti Sains Malaysia,
Pulau Pinang, Malaysia
e-mail: fakrurrozi@usm.my

ORCID AND DISTRIBUTIONSHIP
Ali Jasim Mohammed: 0009-0003-2254-5407 A B D
Ahmad Fakrurrozi Mohamad: 0000-0002-5916-8444 A B E F
Muhammad Annurdin Sabarudin: 0000-0003-4705-2273 D E F
Husniyati Roslan: 0000-0001-8128-2465 E F

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