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The Peri-implant Phenotype and Implant Esthetic Complications. Contemporary Overview

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One sentence summary: Thorough knowledge and assessment of the peri-implant phenotype is critical for management and avoidance of implant esthetic complications.

Abstract

Objective. To provide a contemporary and comprehensive overview of the hard and soft tissue biological structures surrounding an osseointegrated dental implant (peri-implant referred to as the peri-implant phenotype), in the context of peri-implant esthetic complications.

Overview. The individual components of the peri-implant phenotype (keratinized mucosa width, mucosal thickness, supracrestal tissue height, and the peri-implant buccal bone) have been linked to different aspects of implant esthetics, as well as health-related aspects. At the time of implant therapy, respecting the biology of the peri-implant hard and soft tissues, and anticipating their remodeling patterns can alleviate future esthetic complications.

Conclusions. While the current literature may not allow for a point-by-point evidence based-recommendation for the required amount of each peri-implant structure, bearing in mind the proposed values for the components of the peri-implant phenotype, at the time of and prior to implant therapy can lead to more predictable treatment outcomes, and the avoidance of esthetic complications.

Clinical Significance

Knowledge of hard and soft tissue components surrounding and osseointegrated dental implant, and their underlying biological remodeling process is crucial for carrying out a successful therapy and alleviating possible future esthetic challenges.

Key words: Dental implants, Esthetics, Alveolar Process, Phenotype, Periodontics, Gingival Recession, Evidence-based dentistry

1. Introduction

Dental implants have become a common and reliable tool for replacement of missing teeth. Ever since their introduction in the dentistry, an abundance of research has been conducted to investigate different aspects related to their survival and success [1-3]. Nonetheless, with the increasing interest in dental implant therapy among both patients and clinicians, there has also been a rise in the incidence of their complications and adverse events [4-6].

In the case of an osseointegrated dental implant, complications can be categorized as technical/prosthetic-related factors (such as screw loosing of an implant crown or chipping of a prosthetic component) [2, 7], or biologic-related aspects that directly affect the health of the implant (such as the emergence of peri-implant diseases)[8, 9], and lastly patient-related components, some of which are subjective (e.g., post-surgical morbidity), and others that can be assessed both by the clinicians and the patients themselves (such as a treatment's esthetic result).

In the scope of biological complications, peri-implantitis which is an irreversible pathological condition characterized by loss of implant's supporting bone, is an increasing challenge for dentists around the world [9]. According to the 2017 World Workshop on the Classification of Periodontal and Peri-implant Diseases and Condition control [10] , the major risk factors associated with this condition are: a history of periodontitis, poor plaque control, as well as non-compliant maintenance. At the implant level, the effect of the peri-implant soft tissues on the long-term maintenance of implant health has also gained considerable interest. While the evidence in this topic remains equivocal, it appears that keratinized mucosa may present advantages relative to patient comfort and ease of plaque control [10, 11]. Another risk indicator for the onset of peri-

implantitis is an improperly positioned implant, or an inadequate design of its suprastructure [12-14], which may also lead to other implant-related complications, such as an adverse esthetic outcome. The peri-implant esthetic result is influenced by the esthetic appearance of the soft tissues as well as the esthetics of the prosthetic reconstruction [15]. Other than prosthetic components (e.g. marginal integrity, contour, color, and shape), esthetic complications are essentially the manifestation of hard and/or soft tissue deficiencies that have occurred following implant placement, many of which may not be revealed in the short-term.

A hard tissue deficiency after implant placement can be as a result of a pre-existing alveolar ridge deficiency, a peri-implant inflammation, implant malpositioning, and inadequate soft tissue thickness [16]. A soft tissue deficiency however, can be related to the absence of the buccal bone, reduced papilla height, and the lack of keratinized mucosa [16].

Collectively, the hard and soft tissues that surround a dental implant comprise the peri-implant phenotype [17]. In the current article, we present a contemporary narrative of the individual components of the peri-implant phenotype, and their implication to peri-implant health and esthetics.

2. The peri-implant phenotype

The 2017 World Workshop suggested the universal adoption of the term "periodontal phenotype" to describe the traditional term "periodontal biotype", which is a composed of the gingival phenotype (gingival thickness and the keratinized tissue width), as well as the bone morphotype (thickness of the buccal bone plate) [18]. The term "peri-implant phenotype" was recently described analogous to the periodontal phenotype as the morphologic and dimensional

features of an osseointegrated dental implant, comprising a soft tissue component, including the peri-implant keratinized mucosa width, the mucosal thickness, and the supracrestal tissue height, and an osseous component, which is the peri-implant bone thickness [19]. Similar to the periodontal phenotype, the peri-implant phenotype is site-specific and vulnerable to change due to environmental factors [20] or clinical interventions [11, 21]. In essence, the peri-implant phenotype can be referred to as the three-dimensional tissue volume around implants, which is significantly related to the peri-implant health.

3. Implant esthetic complications and common causes

Although an esthetically pleasing outcome may be subjective in nature, several objective assessment tools have been developed over the years to evaluate the esthetic outcome of an implant in the esthetic zone. These include the Pink Esthetic Score (PES) [22, 23], the Papilla Index (PI) [24], the Implant Crown esthetic Index (ICAI) [23], and the modified-ICAI [25].

The PES and PI have been correlated with the patients' responses in relation to the peri-implant soft tissues. In addition, the ICAI and mod-ICAI have also shown a correlation between their objective and subject assessment relative to peri-implant mucosa and implant-supported crown assessment [26].

It is hardly surprising that a patient's subjective perception would be less critical than an objective assessment by a dentist [25, 26]. The rating of a peri-implant mucosa by clinicians and patients was reported to be less satisfactory when compared to the contour or color of an implant-supported crown, especially in areas which has received an augmentation procedure

prior to the implant therapy [27]. In other words, it is more challenging to reach a satisfactory esthetic result in the case of a pre-existing hard and/or soft tissue defect.

The most prevalent implant esthetic complication is an asymmetric appearance of the peri-implant mucosa level, followed by an incomplete fill or lack of papilla, as well as an unnatural color of the soft tissues, and an esthetic void (e.g., volume deficiency/concavity, mesial open contact, etc.). Commonly, a mid-facial mucosal defect which has been defined as a peri-implant soft tissue dehiscence/deficiency (PSTD) [28], particularly in the case of immediate implant placement is one of the main esthetic concerns (Figure 1). It has been reported that a volumetric change within 1 mm is typically not noticeable by the patients [29-31]. However, when even a minimal PSTD is concomitant with/characterized by the exposure of the metallic component of the abutment or the fixture, patients tend to be unsatisfied about the overall implant treatment [28, 32].

A deficient papillary fill is also not a rare event with implant therapy, especially when multiple implants are position in the anterior area. While for patients with a low smile line this may not necessarily pose a significant challenge, in those with a high smile line, however this can be a major esthetic concern [33].

4. The soft tissue components of the peri-implant phenotype and their impact on implant esthetics

4.1. Keratinized mucosa width

The peri-implant keratinized mucosa width (KMW) is the dimension of keratinized soft tissue in an apico-coronal direction measured from the mucosal margin to the mucogingival junction [19].

In the scientific literature, the threshold to define an "adequate" KWM for maintaining optimal peri-implant health has frequently been defined as 2 mm [19, 34-36]. Despite existing controversies in this field [37], the absence of an adequate KMW around implants has been associated with higher likelihood of plaque accumulation, gingival inflammation, and mucosal recessions [35, 38-43]. KMW augmentation with apically positioned flap and free gingival graft procedure can result in probing depth reduction, as well as lower plaque scores and less chance for future mucosal recession [11].

However, an abundance of keratinized mucosa may not be as relevant to peri-implant esthetics, as it is to peri-implant health. In other words, the natural appearance of soft tissues around a dental implant is mainly dictated by the position, color, and texture of the peri-implant mucosa [44, 45].The typical appearance of a limited or lack of KMW is commonly caused by a severely deep implant placement (likely due to the an underlying hard tissue deficiency at the time of placement) followed by the lack of apically positioning the keratinized tissue at the time of implant uncover (second stage), or simply excessive localized trauma from previous surgical procedures.

Arguably, in such cases, the challenge to the esthetics predominantly arises from an inaccurate crown height or the alteration of the mucosal margin; that is to say, that an asymmetric gum line is often what attracts attention and is often the underlying cause of the esthetic concern, rather than an unnatural soft tissue appearance (Figure 2). Nevertheless, the color and texture of peri-implant mucosa on the facial aspect can be significantly influenced by the amount of keratinized mucosa, tissue thickness, and the inflammatory edema which may be exacerbated by an insufficient keratinized tissue, especially in patients who tend to comply less

with maintenance recalls [46]. Lastly, it has to be mentioned that patients typically prefer the esthetics of an implant with a zone of keratinized mucosa over implants without [47].

In conclusion, a lack of KMW may not directly lead to an esthetic concerns while, its presence can maintain a more natural soft tissue architecture and color, similar to that of its contralateral natural dentition, and reduce the risk for the occurrence of peri-implant inflammation, and avoid progression of a mucosal recession.

4.2. Mucosal thickness

The peri-implant mucosal thickness (MT) refers to the horizontal dimension of the peri-implant soft tissue, which may or may not be keratinized (figure 3). It is commonly measured at 1 to 2 mm apical to the mucosal margin, depending on its measurement method; and may vary according to different implant locations (e.g., buccal versus lingual) [19]. In the past decade, a great deal of the published research has focused on the horizontal measurement of the mid-facial peri-implant mucosa (at the most coronal segment on the implant shoulder) for assessing the esthetic outcomes of implant therapy [48-53]. Mainly the "masking" effect of the peri-implant soft tissues on the shade of different abutment materials have been evaluated, and it has been reported that ≈ 2 mm of tissue is the minimal thickness required for having the least noticeable color changes on zirconia abutments [52]. While an *in vitro* study, it was found that a MT of 3 mm was capable of masking all restorative materials [54], the current recommendation is that MT should be of at least 2 mm for avoiding discoloration of the soft tissue due to the restorative materials.

The presence of a thick biotype, as determined by probe visibility (> 1 mm) [55] was also demonstrated to have a higher resilience towards the incidence of a mucosal recession following

immediate placement [56]. Thus, mucosal thickness augmentation has been advocated for compensating an underlying bone deficiency, or the expected bone remodeling in the case of an immediate implant placement, for promoting a more stable facial soft tissue profile over time [57-62]. A recent systemic review and network meta-analysis have confirmed the benefit of phenotype modification in augmenting the peri-implant MT, relative to marginal bone level stability [11]. While up to this day, a consensus on the minimal required amount of MT for achieving predictable long-term functional and esthetic outcomes is still missing [63], a threshold of 2 mm in thickness has been proposed for reducing the impact on the esthetic outcomes in the daily practice [19].

The term "peri-implant mucosa thickness" or "peri-implant soft tissue thickness" has also been used to incorrectly refer to the vertical dimension of soft tissues on the crestal bone [64-67] or the distance of the peri-implant mucosal margin to the level of bone to implant contact [68]. Later on, as researchers have explored the influence of soft tissues to crestal bone stability around implants; the term was redefined as the "vertical soft tissue thickness on crestal bone" to distinguish it from the horizontal dimension [69, 70]. Today, this dimension is collectively referred to as the "supracrestal tissue height" [19], and a positive correlation has been shown between this soft tissue component and a thick peri-implant phenotype (greater "supracrestal tissue height" associated with the thicker peri-implant phenotype) [71].

In conclusion, the peri-implant mucosal thickness (MT) is significantly related to a risk for esthetic complications. Not only does a thin mucosal margin predispose the site to a more drastic bone remodeling, but also the presence of a minimal amount of mucosal thickness (2 mm) can diminish the possibility of appearance of the shade of the abutment. Additional soft tissue grafting procedures are recommended to overcome visibility of the metallic shade of titanium

abutments or for compensation of a thin MT for immediate placement of dental implants, or in the case of a pre-existing bone deficiency.

4.3. Supracrestal tissue height

The peri-implant supracrestal tissue height (STH) refers to the vertical dimension of the soft tissue surrounding a dental implant, which is from the mucosal margin to the crestal bone [19]. Clinically, it can be circumferentially determined by transmucosal sounding with the periodontal probe, and its dimension includes the sulcular epithelium, the junctional epithelium, and the supracrestal connective tissue. It is greater in interproximal areas and is usually 1-1.5 mm higher than the corresponding gingiva [72]. In an animal model, it was found to average about 3.4 mm and tends to be shorter in the case of epicrestal bone-level implants [73].

STH is usually assessed during the surgery, either at the time of implant placement or at second stage, by using a probe. However, this method is not feasible for follow-up visits. Ultrasonography has shown to be a non-invasive and reliable tool for assessing peri-implant soft and hard tissues in real-time [74-76].

Unlike natural teeth, the STH reflects the fact that the supracrestal connective tissue is not attached to the implant abutment surface; hence, STH should not be used interchangeably with the term "supracrestal tissue attachment" around natural teeth, which has recently been proposed to replace the classical term "biologic width" [18]. The principle of "biologic width" had comprised the junctional epithelium and the supracrestal connective tissue [77] to be associated with the physiologic establishment of the peri-implant biologic space to protect the bone level [78-80]. It not only dictates the dimension of the facial bone crest, but may also explain the findings

that a thin tissue height at the time of implant placement tends to be associated with the marginal bone loss (MBL) [69, 70, 81, 82]. This rationale is supported by current evidence irrespective of the implant design (e.g. bone or tissue level implant), or the restorative modality (e.g. platform switching or laser modification) [19]. A recent systemic review confirmed that a thick STH (> 2mm) could have a protective effect on the MBL around crestally-positioned implants, compared to a thin STH (≤2 mm) [83]. However, recent evidence suggests that a short prosthetic abutment is the true predisposing factor of early marginal bone loss despite vertical mucosal thickness [84-86].

To evaluate the risk of esthetic complications, it is important to realize the correlation between peri-implant tissue dimensions and the "periodontal phenotype". It was reported that a "flat-thick" periodontal phenotype combined with a more square-shaped tooth contour exhibited a greater STH than a "scalloped-thin" phenotype with a slender triangular crown form [87, 88]. In addition, STH is strongly associated with greater papillary volume, which is usually ≤ 5 mm between an implant-supported crown and a natural tooth in case of a complete fill [89-91] and is dictated by the connective tissue adhesion level at the adjacent interproximal tooth surface [71, 92]. It was averaged to about 3 mm between two adjacent implant restorations, and its regeneration has proven to be unpredictable, due to its dependence on the underlying supporting bone [91, 93, 94]. As such, to predict the esthetic of the papilla, the morphology of an interproximal space should be evaluated prior to the implant placement, including assessment of STH [95, 96]. In the management of esthetic complications commonly induced by a “deep implant placement”, "mucosal thickening" or "phenotype medication" to cover the peri-implant dehiscence by multiple layers of connective tissue grafts, or an acellular dermal matrix with a bilaminar approach has been proven effective control [11, 97]. The key ingredient of success relies

on the abutment design with a reduced-diameter to preserve the adhesion of a good-quality connective tissue; and subsequent manipulation of the emergence architecture of peri-implant soft tissue volume.

In addition, orthodontic extrusion can also be supplemented to re-establish the ideal height of supracrestal tissues between implants and adjacent teeth. However, the long-term (>5 years) outcomes of soft tissue augmentation around implants, especially in the presence of a buccal bone dehiscence, has yet to be elucidated [98, 99].

Recent evidence indicates that when implants are placed deeper with a mucosal tunnel depth ≥ 3 mm (above the implant-restorative platform), the resolution of peri-implant mucositis can take longer, and proper oral hygiene can be hindered, compared to a shallower implant position with a mucosal tunnel ≤ 1 mm [100]. The tunnel refers to the distance between the bottom of sulcus and the mucosal margin, and taking into account the smooth 1.8 mm collar of the implant, STH ≥ 5 mm presented with higher risk for peri-implant mucositis compared to STH < 3 mm (Figure 4). Similarly, a recent study showed that an excessive STH in patients with previous history of periodontitis was correlated with increased pocket depth and marginal bone loss, with the risk for peri-implantitis that increased 1.5 times for 1 mm increase of STH [101]. Given the anatomic and restorative variations, Avila-Ortiz et al. proposed the threshold of 3 mm for definition of a "short STH" (< 3mm) versus "tall STH" (≥ 3 mm) to avoid esthetic complications that dental implants should be placed "as deep as necessary, but as shallow as possible"[19].

In conclusion, the STH to re-establish a biologic space for the implant-supporting apparatus is essential to protect and maintain the peri-implant bone. The risk of esthetic complications can be avoided by prudent examination of the interproximal periodontal attachment of adjacent

teeth, and possibly by "modified" by soft tissue augmentation. Yet, the long-term stability of soft tissue augmentation warrants more evidence. Ultimately, the best way to prevent esthetic complications is ensuring an ideal 3D implant positioning and proper abutment design for the STH establishment around dental implants to minimize the peri-implant bone loss.

4.4 Level of the soft tissue margin

The level of the soft tissue margin (STM) in the midfacial aspect plays a crucial role on the esthetic appearance and health of the implant [28, 97]. When the STM is not at the level of the homologous natural tooth, a peri-implant soft tissue dehiscence/deficiency (PSTD) is diagnosed. The term PSTD includes conditions with: i) deficient peri-implant soft tissue volume compared to the adjacent sites, or thin MT that makes the color of the abutment/implant fixture visible through the mucosa, ii) apical shifting of the peri-implant STM compared to the homologous natural tooth with concomitant exposure of the abutment and/or the implant fixture (with the implant-supported crown having the same height as the crown of the homologous tooth), iii) apical shifting of the peri-implant STM as a consequence of an implant-supported crown longer than the one of the homologous tooth, iv) a combination of these scenarios (figure 5) [28, 97, 102].

While discrepancies between the level of the peri-implant STM and/or the height of the implant-supported crown compared to the gingival architecture of the adjacent teeth are mainly esthetic complications that may affect patients' perception of the overall implant therapy, PSTDs with exposure of the abutment or implant fixture can impair peri-implant health. Indeed, the exposure of the rough surface of the implant to the oral cavity creates an environment for bacterial colonization, drastically increasing the change of developing peri-implant diseases.

Several etiological factors for PSTDs have been identified, including inadequate KMW and/or MT, buccally positioned implant platform, overcontoured prosthesis and traumatic toothbrushing [97, 103, 104]. Bearing in mind that the etiology must be eliminated before treating these conditions, the primary goal for the treatment of PSTD is to reposition the STM (and the crown margin) at the same level of the homologous tooth, with an adequate peri-implant soft tissue phenotype and volume [28, 105]. Our group recently proposed a classification of PSTDs based on the level of the STM and the bucco-lingual position of the implant crown and platform [28]. While evidence for PSTD treatment is still limited in the literature and mainly based on case series, it seems that coronally advanced flap and connective tissue graft, either with the combined surgical-prosthetic approach [106] or with a submerge technique [107], is the approach of choice for these conditions.

5. Osseous component and the impact on the implant esthetic complications

5.1. Peri-implant bone thickness

The peri-implant bone thickness (PBT) is the horizontal dimension of the osseous tissues supporting an osseointegrated implant. The alveolar bone housing around the osseointegrated implant is the foundation to support the soft tissues which is considered a necessity for obtaining esthetic outcomes in the anterior zone. There is a wealth of studies investigating the peri-implant bone volume, and the evidence indicates that PBT varies at different heights relative to the bone crest [108] and that a thicker bone, particularly at the coronal level, favors the esthetic and functional outcomes of implant therapy [109]. A study reported that without guided bone regeneration (GBR) of bone dehiscences around implants, the probability of future bone loss

increased to two folds [110]. The efficacy of lateral augmentation to increase bone thickness around implants was confirmed by a recent systematic review, which also found a reduction of 0.15 mm in mucosal recession at sites undergoing GBR [111]. Interestingly, it was shown that even with significant dehiscence-type bone loss long after GBR was performed around immediate implants, the mucosal levels remained relatively unchanged [112, 113]; while larger dehiscence defects, increased the likelihood of mucosal recessions and peri-implant diseases [113, 114].

Despite limited evidence for distinguishing a clinical threshold of bone thickness to sustain the peri-implant tissue stability, esthetic and health, findings from a prospective study indicates that a bone thickness ≥ 2 mm leads to significantly less bone loss after implant uncovering [115]. A recent preclinical study further explored the concept of "critical bone thickness" and concluded that a minimum thickness of 1.5 mm was needed to avoid further physiological bone remodeling and to have less pathologic bone loss [116]. Therefore, in the meantime a threshold of 2 mm can be used for categorization of a thin versus thick PBT (< 2 mm: thin; ≥ 2 mm: thick), for clinical guidelines.

Taking into account the surrounding bone volume when placing implants in the restoratively-driven position can aid in determining the need for potential ancillary bone grafting. As a thin bone morphotype around an implant may accompany a more aggressive bone resorption pattern due to disturbance of the surrounding blood supply [117], particularly when implants are placed far too buccal relative to the bony housing (Figure 6). Thus, thorough assessment of the sagittal root position in the anterior maxilla is crucial when planning an immediate implant placement [118]. When an unfavorable root position (e.g., when majority of the root is engaging both buccal and

palatal cortical plates) in combination with a thin PBT is encountered, additional bone grafting and/or soft tissue augmentation is recommended.

In conclusion, the peri-implant bone thickness is determined by the final implant placement which can be improved by lateral bone augmentation to convert a thin bone morphotype to a more favorable peri-implant bone thickness. The importance of PTH for the long-term stability of soft tissues and ridge contour is widely accepted. Hence, additional bone augmentation, when feasible can yield the superior esthetic results over time.

6. Concluding remarks

The first most effective and indeed the first step towards management of a complication is the initiative towards its prevention. In the context of peri-implant health and esthetics, this includes conservative management of the existing natural dentition, and their surrounding tissues with respect of the of the biologic principles [119] and reconstitution of both hard and soft tissue deficiencies, when indicated [120].

Bearing in mind the “ideal” components of the peri-implant phenotype, our aim at the time of implant therapy, should be to create peri-implant tissue architectures that mimic the contralateral periodontal tissues and allow the re-establishment of the traditional concept of "biologic width" (currently referred to as supracrestal tissue attachment).

As such, implants should be placed:

(a) at least 1.5 mm from adjacent teeth in the mesiodistal direction

(b) 3-4 mm apical to the anticipated mucosal margin in the coronoapical direction

(c) at least 3 mm palatal to the facial curvature of the arch in an orofacial direction, and at the level of mucosal margin considering 2 mm bone thickness and 1 mm mucosal thickness; or alternately at a cingulum position.

By understanding the underlying tissue characteristics and the phenotype, we should predict the direction of tissue remodeling that is associated with thin hard and soft tissue phenotypes, and proactively compensate the estimated remodeling to reduce esthetic complications.

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Figures Legends

Figure 1. Illustrates an example of assessing components of the peri-implant phenotype in the case of an implant placement, and the 1-year outcome of the treatment.

Figure 2. Clinical demonstration of two implants in the anterior region with esthetic complications. Note that both implants were placed deeper relative to the adjacent dentition, and and show reduced keratinized mucosa width. The left image (A) shows an implant in the #8 region with a narrow band of KMW caused by the implant deep placement, showing an unnatural color and altered mucogingival junction due to the previous bone regenerative procedures. Case on the right (B) shows an implant complication in the #8 area with a peri-implant soft tissue dehiscence/deficiency (PSTD), as well as a limited band of KMW, likely caused by a deep positioning, as well as transparency of the abutment through the mucosal margin. The unesthetic and unnatural color of the mucosal margin is also due to the chronic localized inflammation (triggered by an inadequate KMW). The frenum may further impair self-performance of oral hygiene as well.

Figure 3. Example of lack of a thin peri-implant phenotype (keratinized mucosa width, inadequate mucosal thickness, and thin peri-implant bone thickness). Multiple implant-supported crown/bridges in the anterior maxilla with multiple PSTDs, and interproximal bone loss. #9 implant exhibits a suspicious fibroma at the buccal aspect potentially induced by the foreign body reaction to the titanium particles and chronic inflammation around the exposed threads, associated with the lack of KMW. Thin mucosal thickness, allows for the grayish

transparency to show through the margin, and mucosal tattooing was evident which made the deficient ridge volume more obvious.

Figure 4. Example of a deep mucosal tunnel and tall supracrestal tissue height (STH). #12 implant presented with an acceptable peri-implant mucosal margin, but an unnatural color which suffered from persistently chronic inflammation and bleeding on probing, occasional suppuration, and patient discomfort (peri-implant mucositis). The cause of such biological and esthetic complication is the significantly deep placement of the implant which created a deep mucosal tunnel with a tall supracrestal tissue height (STH).

Figure 5. Clinical- and ultrasonographic view of anterior implants with and without soft tissue dehiscence (PSTD). A) Implants without PSTD. B) Implant with PSTD without exposure of the abutment. C) Implant with PSTD with exposure of both abutment and fixture. The dotted black lines in the clinical photographs illustrate the reference (gingival margin of the homologous tooth) for the peri-implant STM, while the white lines indicate that is presented in each ultrasound scan. Ultrasonography shows the implant supported crown (C), abutment (A), implant fixture (I), crestal bone (CB) and soft tissue (ST). This technology allows to assess and calculate STH (from the crown margin to the crestal bone) and MT at different levels.

Figure 6. Example of thin peri-implant bone thickness in the area of #8 implant, which required additional grafting procedure.

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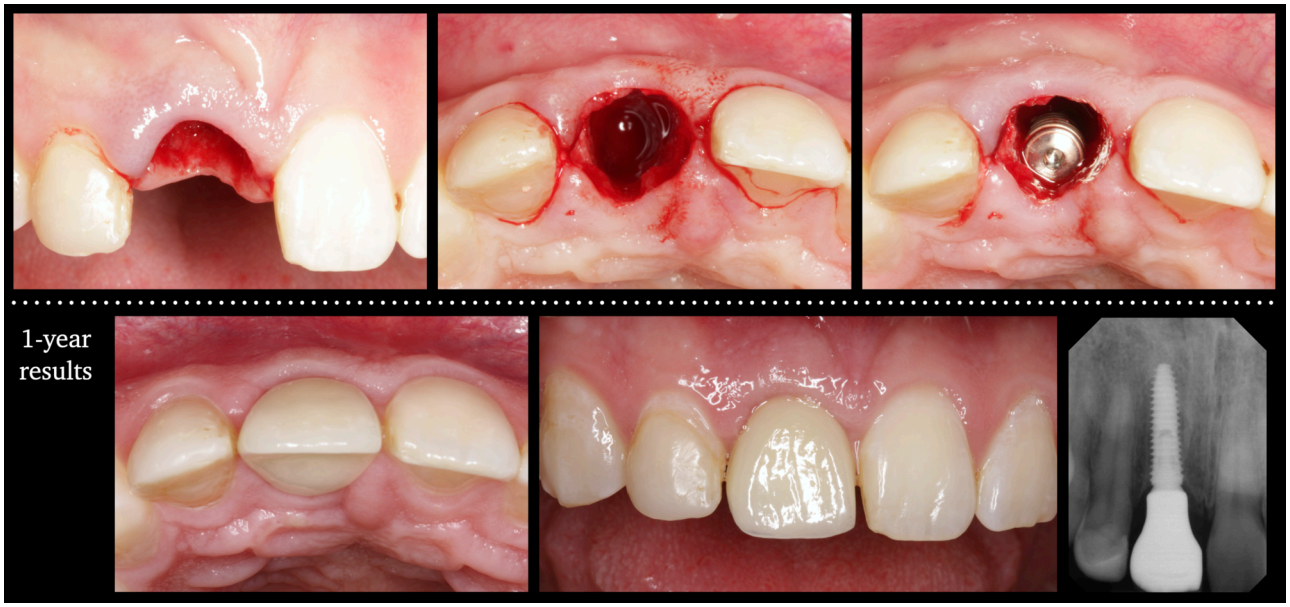

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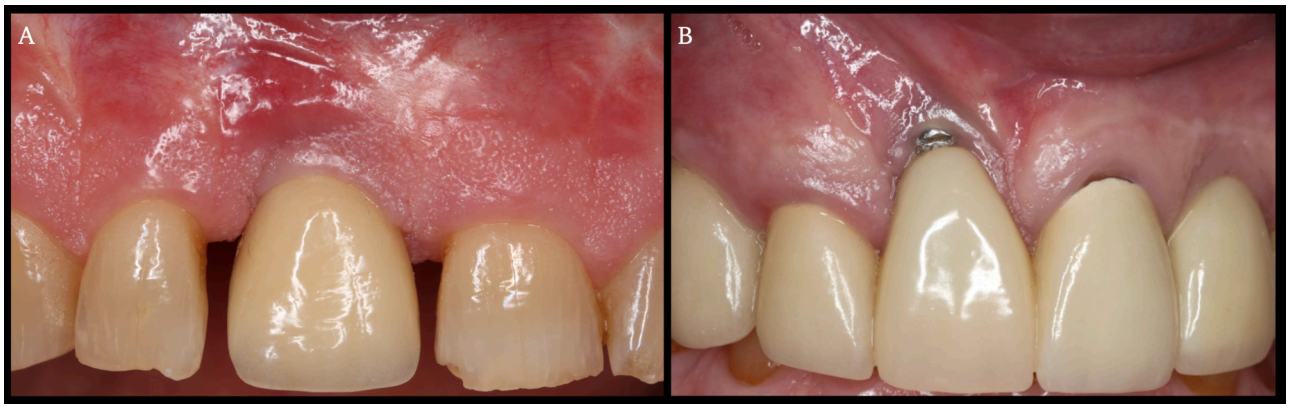

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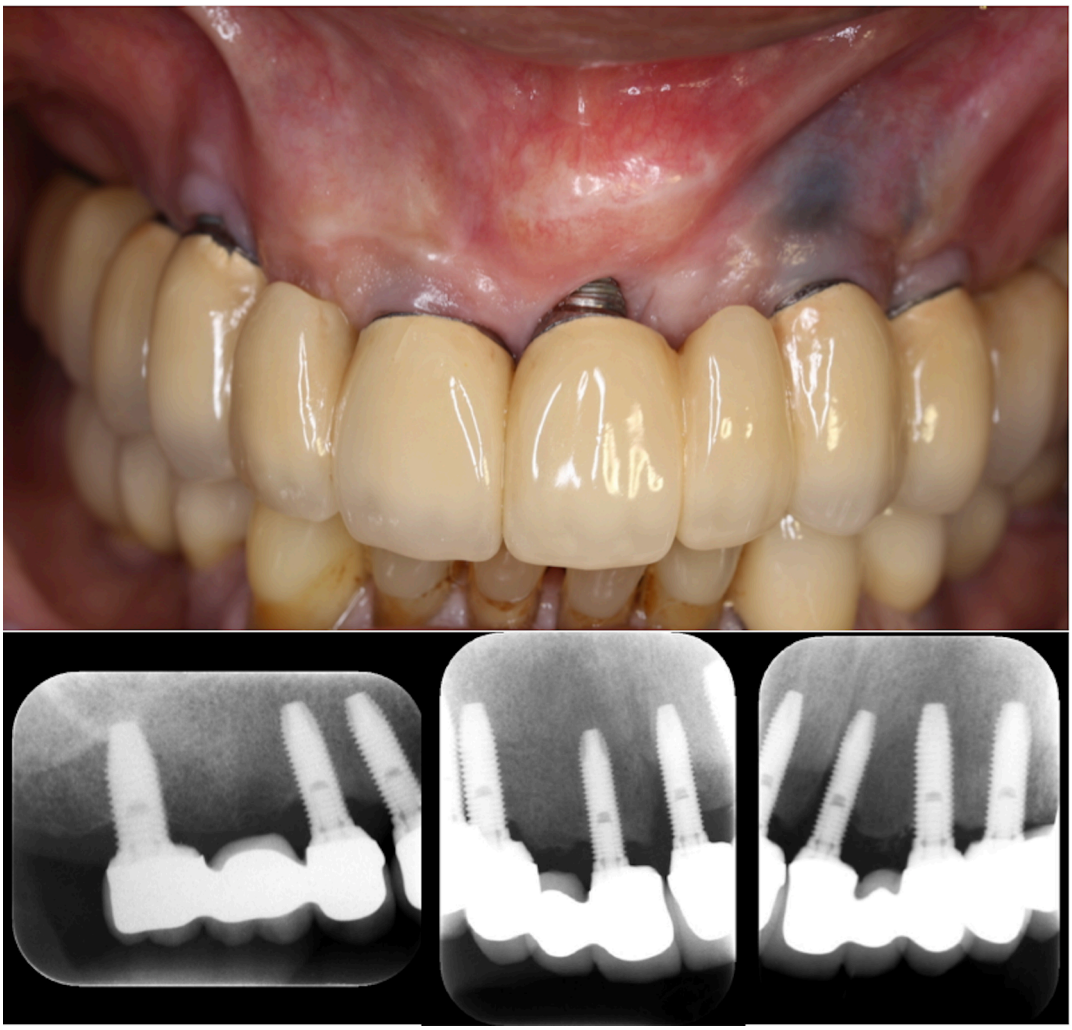

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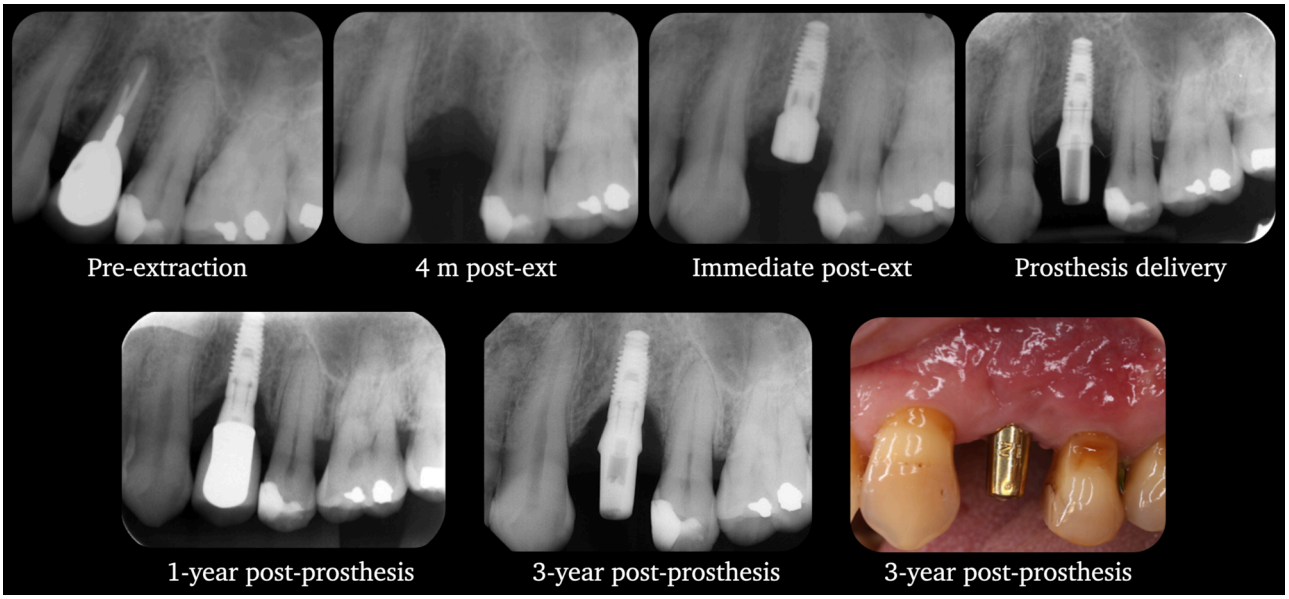

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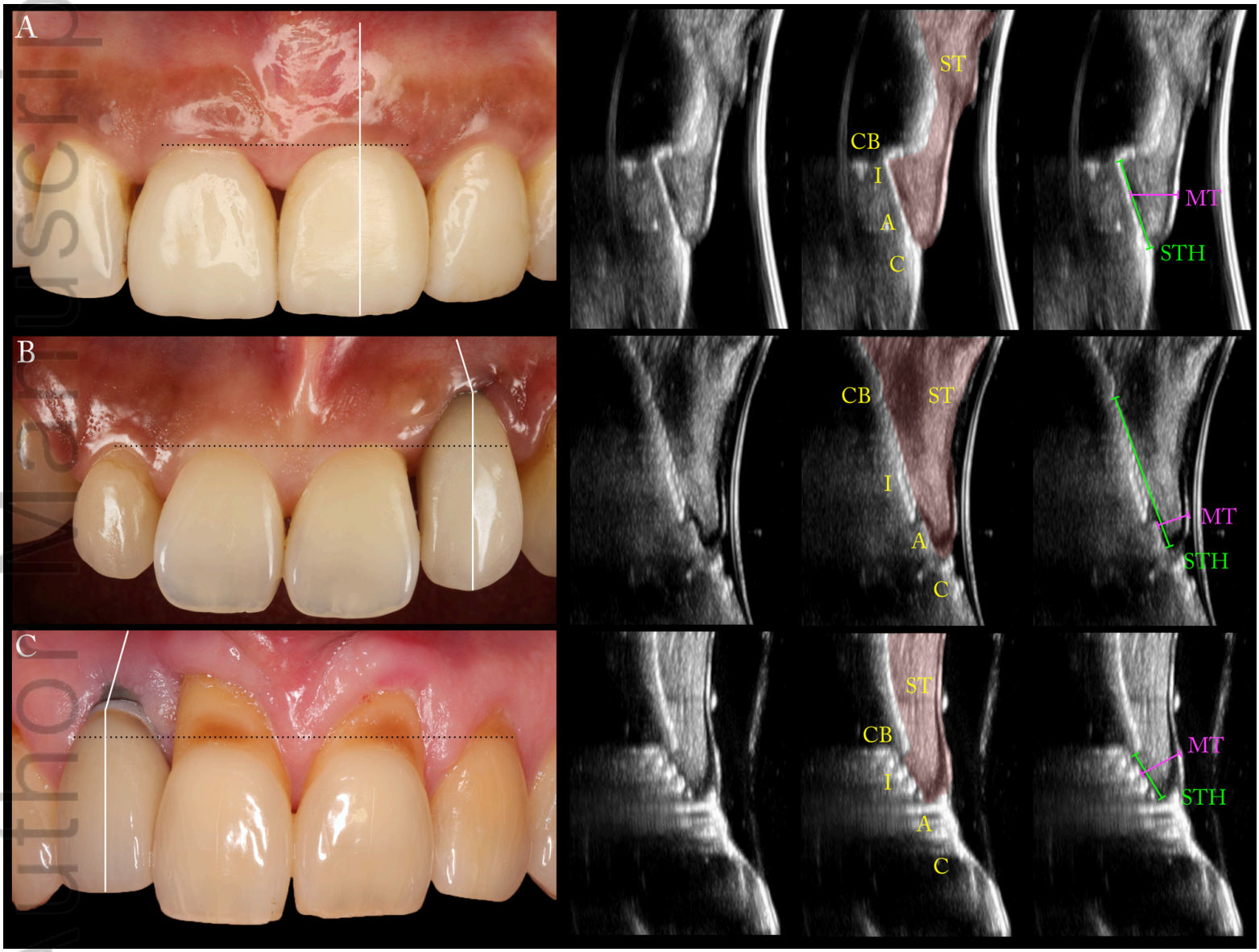

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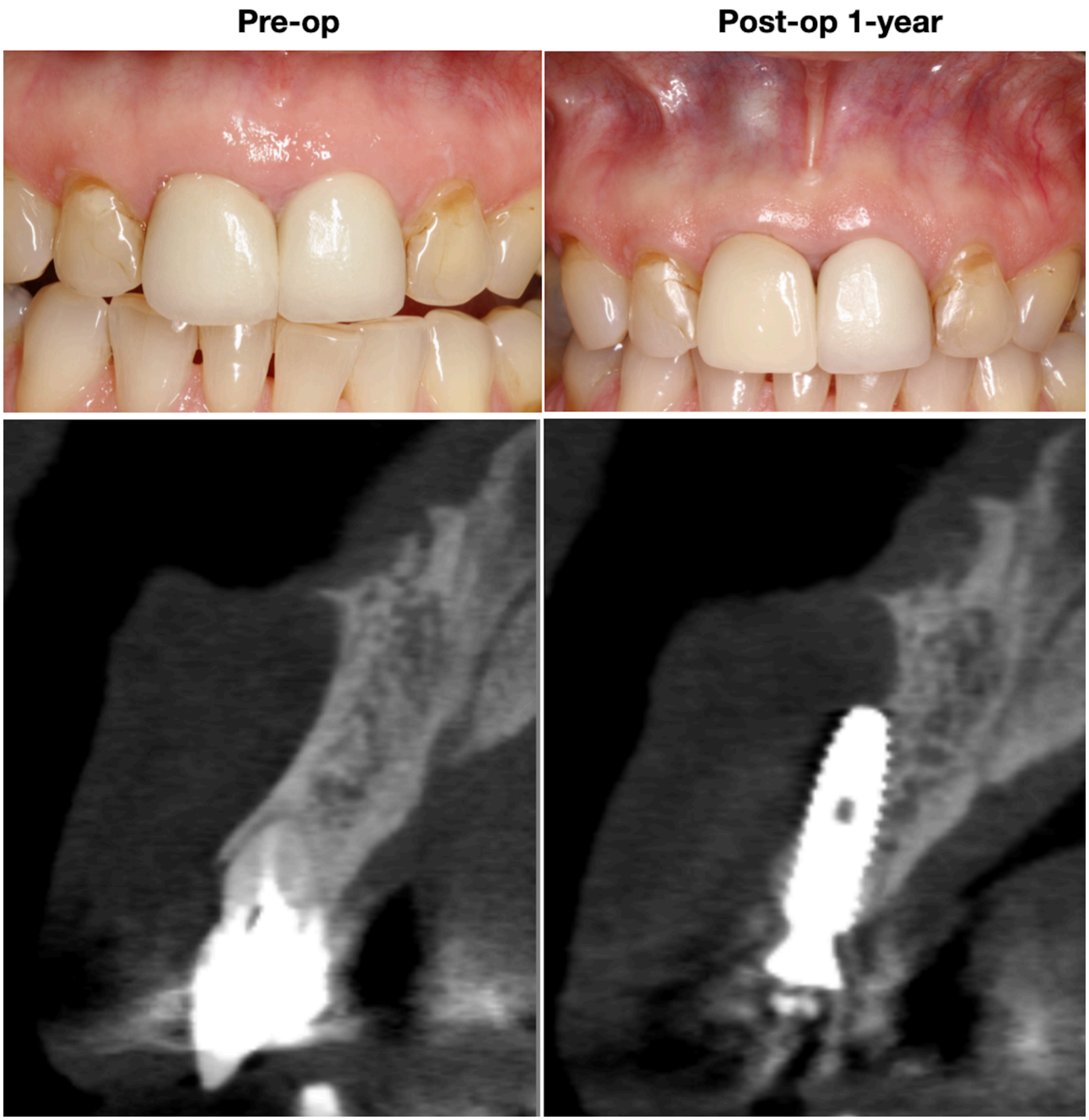

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The Peri-implant Phenotype and Implant Esthetic Complications. Contemporary Overview

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One sentence summary: Thorough knowledge and assessment of the peri-implant phenotype is critical for management and avoidance of implant esthetic complications.