Classification of Peri-implant Diseases and Conditions

A PRACTICAL GUIDE

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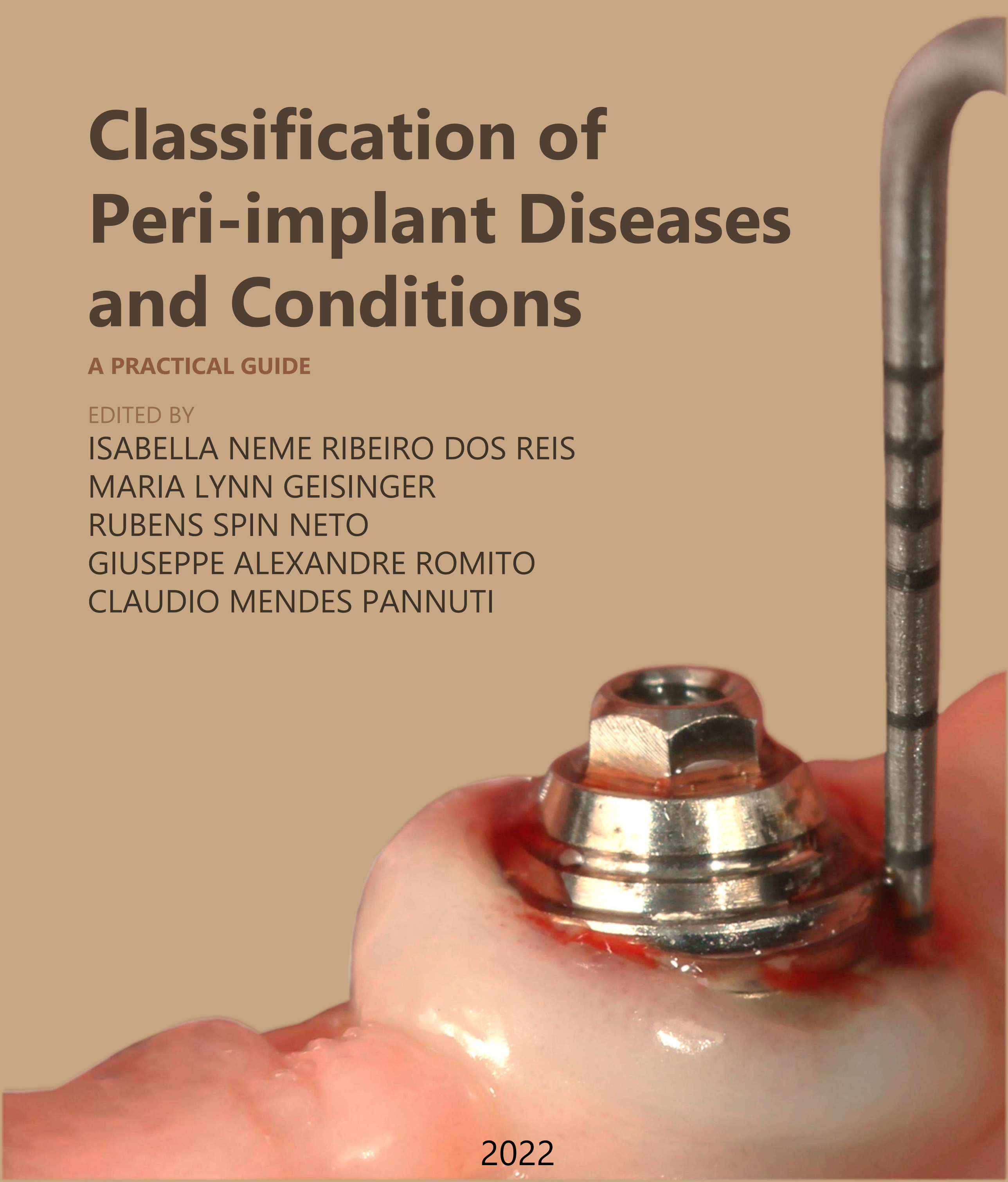

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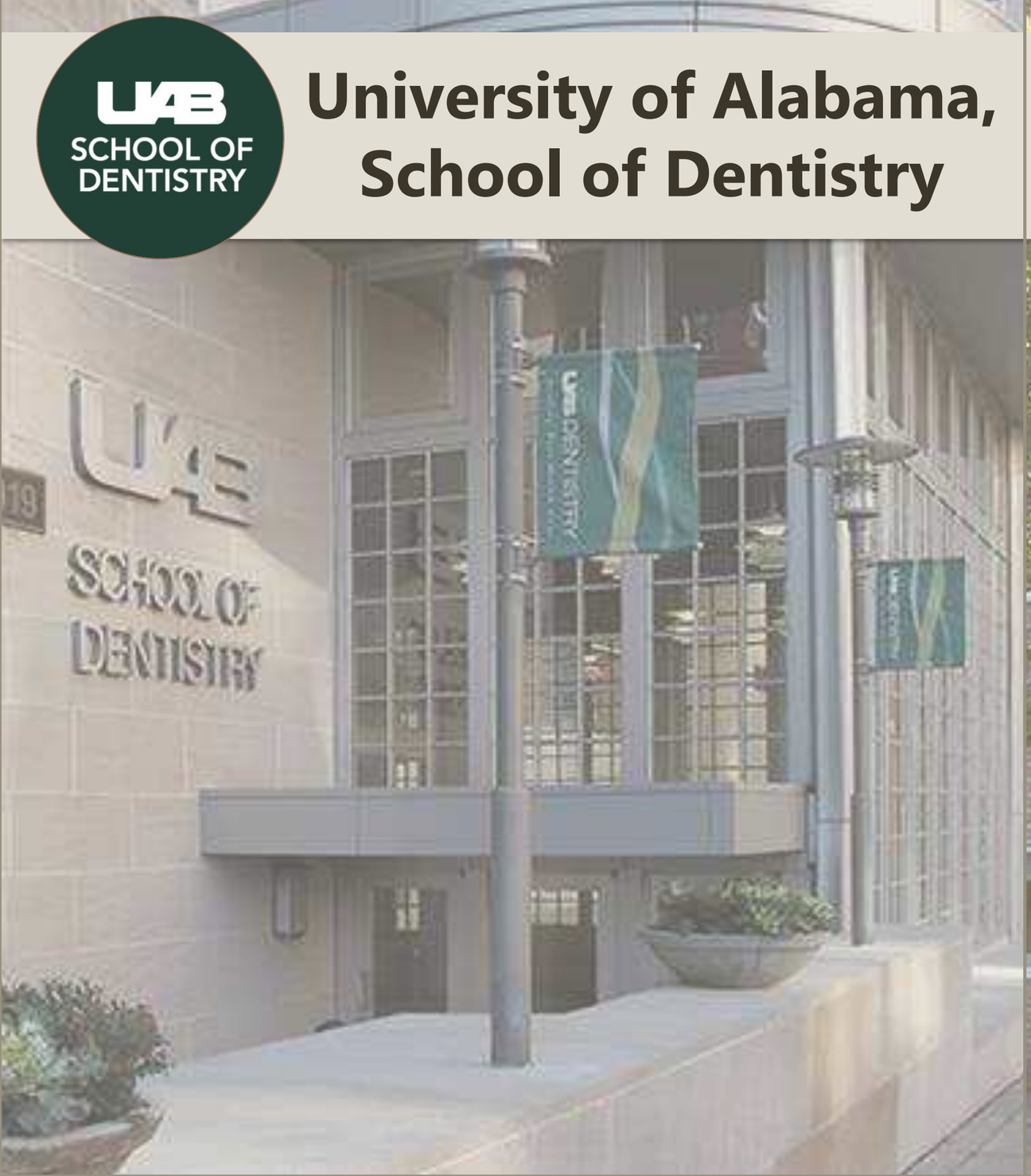

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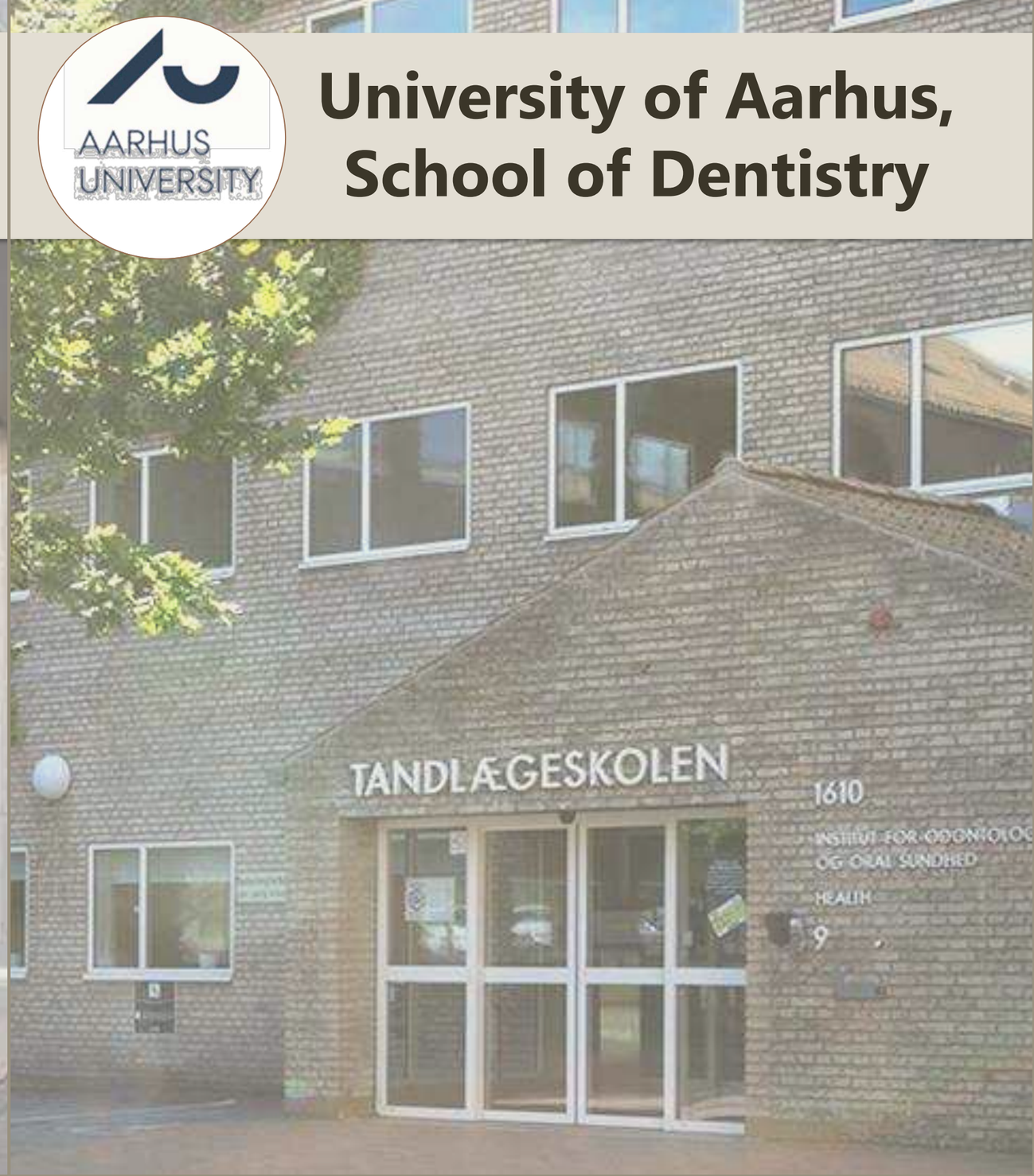

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Why classify peri-implant diseases and conditions?

The use of dental implants in the rehabilitation of missing teeth has grown exponentially and is likely to continue to grow as treatment protocols are improved and become more predictable. However, the increase in the use of implants is accompanied by an increase in complications related to this treatment. Among them, peri-implant mucositis and peri-implantitis are pathological conditions that can occur after successful implant integration and are commonly observed in daily clinical practice.

A meta-analysis showed that the estimated average prevalence of peri-implant mucositis and peri-implantitis is 43% and 22%, respectively, in European and North and South American countries (Derks et al., 2015). Furthermore, a recent clinical study in Brazil revealed that 54.5% of the 211 included individuals had peri-implant mucositis, and 39.8% had peri-implantitis (Matarazzo et al., 2018).

These complications negatively affect the patient in different ways, including the discomfort caused by the diseases, the discomfort associated with their treatment (surgical or non-surgical), the financial impact of this treatment, and/or the possible loss of the implant; all of which represent setbacks for the professionals involved. Considering such repercussions and their high prevalence (Derks et al., 2015, Matarazzo et al., 2018), knowledge about the clinical and radiographic characteristics of these diseases is necessary for the early diagnosis and treatment of the patient.

The most effective and predictable therapeutic approach is the non-surgical treatment of peri-implant mucositis (Renvert et al., 2008, Salvi et al., 2012) before it progresses to peri-implantitis. Peri-implantitis is preceded by peri-implant mucositis; however, the determinants that promote the conversion from peri-implant mucositis to peri-implantitis have not yet been defined. While peri-implant mucositis is reversible after non-surgical treatment, non-surgical treatment of peri-implantitis has shown limited effects on long-term disease progression (Renvert et al., 2008). Systematic reviews (Chan et al., 2014, Valderrama et al., 2013) have demonstrated that a surgical approach is necessary to treat peri-implantitis. However, there is still no consensus on how to efficiently perform it, about decontaminating the implant surface, and about the associated use of hard and/or soft tissue grafts and growth factors. Furthermore, there is no consensus regarding the benefits of long-term treatment of peri-implantitis. When achieved, successful treatment of peri-implantitis occurs only in the short term (Heitz-Mayfield et al., 2014), with 75% of cases unresolved or with disease recurrence after five years (Heitz-Mayfield et al., 2018). Therefore, prevention and diagnosis at early stages are essential for a favorable prognosis.

On the other hand, the diagnosis of peri-implant mucositis and peri-implantitis was a matter of controverse and discussion until recently. Zitzmann et al. (2008) highlighted the lack of a standard in the diagnostic criteria, precisely, the wide variation in bone loss and the specific probing depth value required for diagnosing health or disease. Another review found eight definitions of the level of radiographic bone loss required to diagnose peri-implantitis (Tomasi et al., 2012).

Why classify peri-implant diseases and conditions?

Recently in 2017, at the World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions, organized by the American Academy of Periodontology and the European Federation of Periodontology, criteria for the diagnosis of peri-implant diseases and conditions were standardized for the first time (Caton et al., 2018, Berglundh et al., 2018). This classification system included definitions for peri-implant health, peri-implant mucositis, and peri-implantitis. The authors concluded that implants can be diagnosed as healthy with regular or reduced bone support and that it is not possible to define specific probing depth values for peri-implant health and peri-implantitis, as in the case of periodontal health and periodontitis. Furthermore, they defined a pattern of bone loss that is necessary for diagnosing peri-implantitis (Berglundh et al., 2018, Renvert et al., 2018). In addition, there is a better understanding of the risk factors involved in the incidence and progression of these diseases (Heitz-Mayfield et al., 2020), which were also scored in the classification system. Additionally, peri-implant hard and soft-tissue deficiencies and causing or associated factors were discussed for the first time. Such deficiencies are common findings and may require therapeutic interventions to improve implant treatment outcomes. Understanding the etiology behind them is critical for effective treatment (Hämmerle et al., 2017). This classification system has since been endorsed by the American Dental Association.

Finally, we consider essential the knowledge about the conditions of success, survival, and failure of implants and the functional and esthetic aspects involved in these conditions (Misch et al., 2008). All these topics are discussed in this e-book.

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SUMMARY

CHAPTER
01

Basic anatomy of peri-implant tissues

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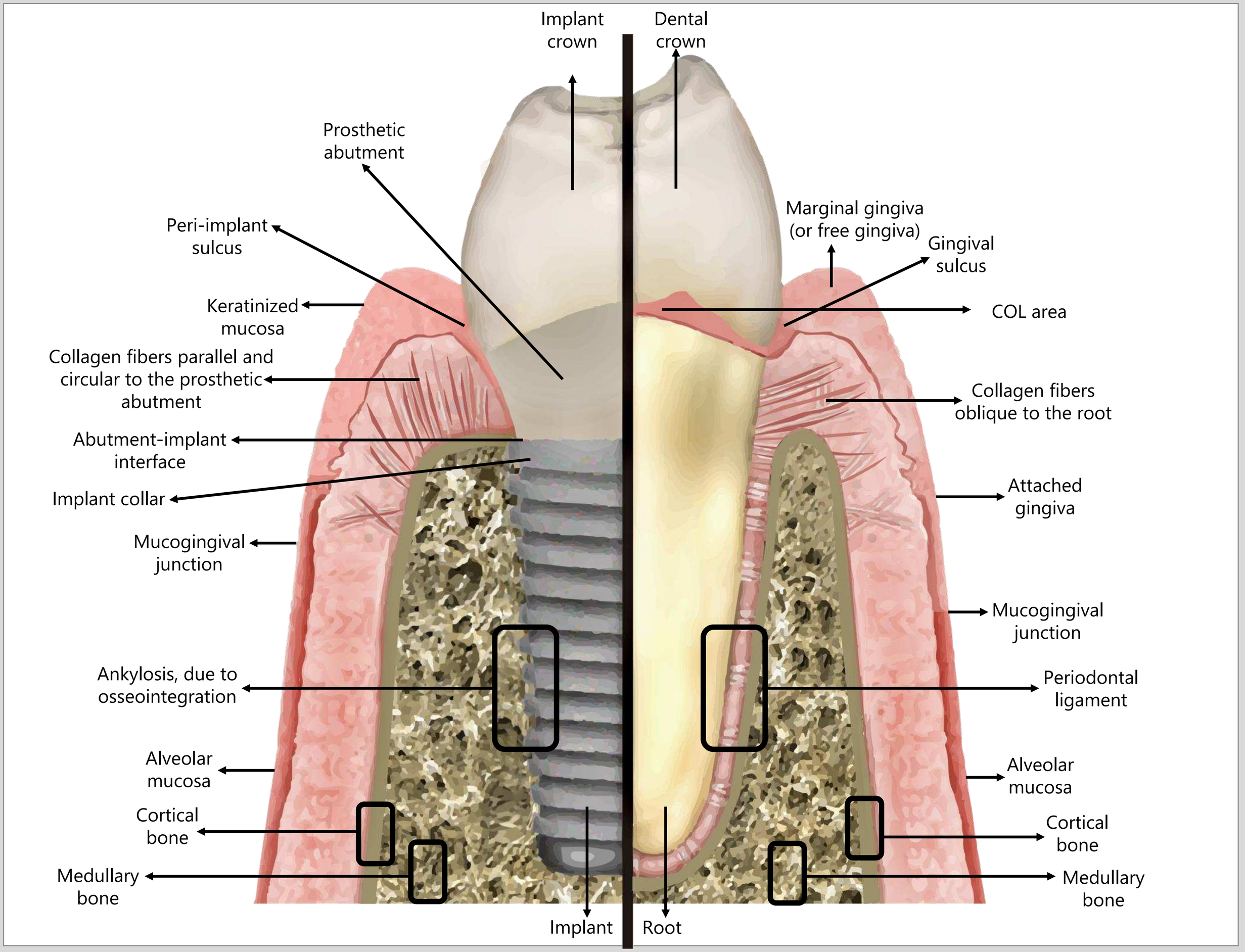
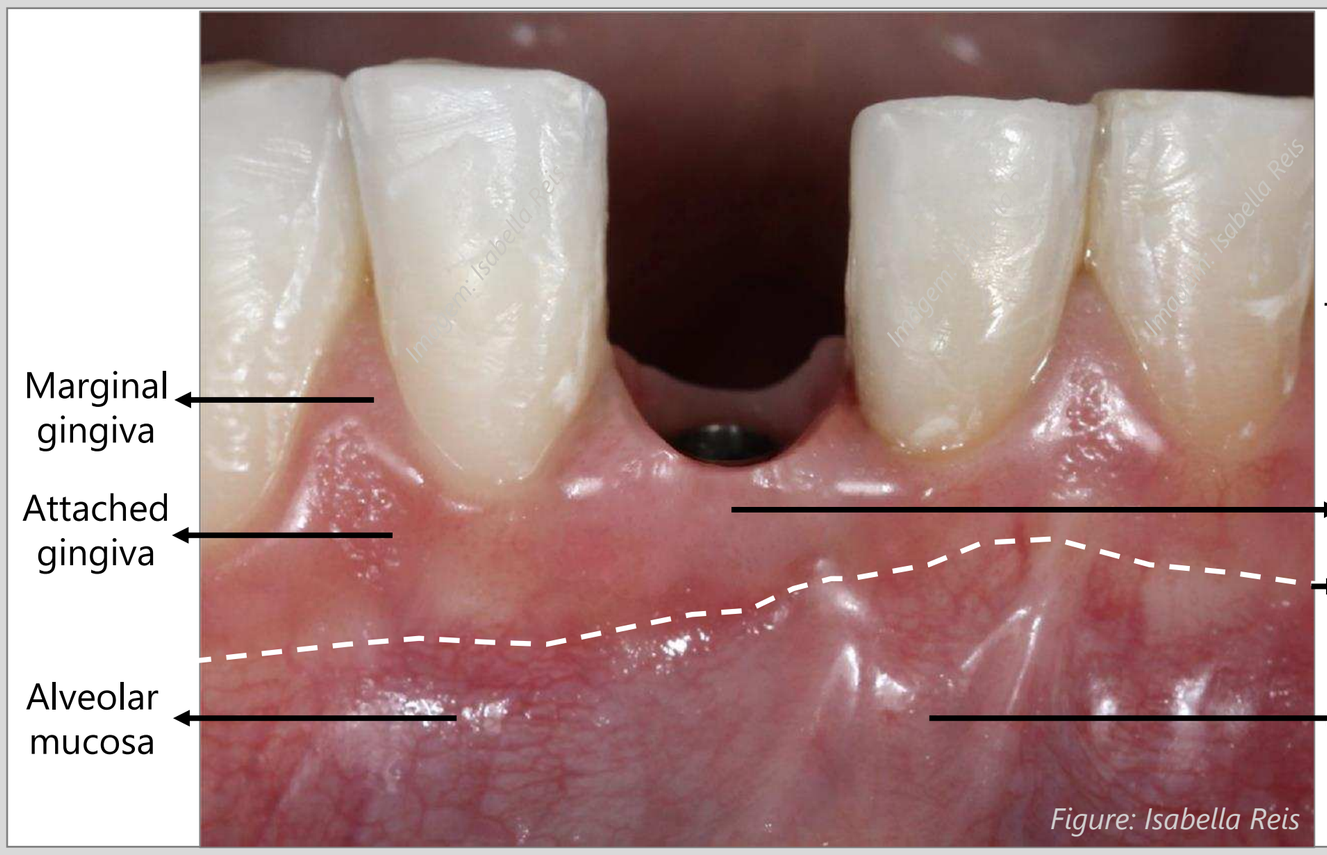
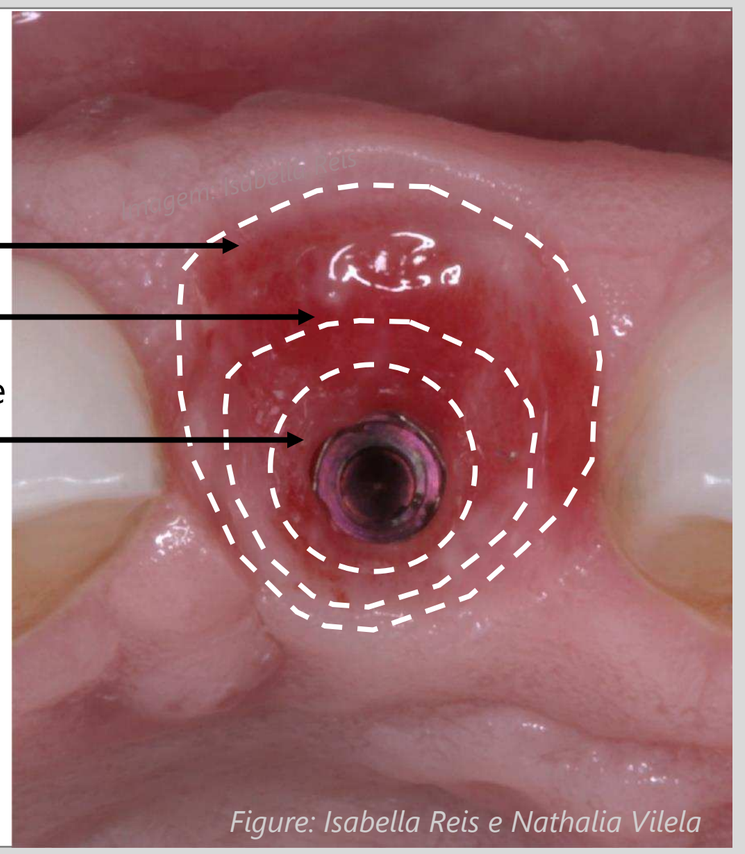
Figure: Isabella Reis

Anatomy of peri-implant tissues







Subtitles - Anatomy of periodontal and peri-implant tissues	
COL area	Interproximal concave area that connects the buccal and lingual papillae. When healthy, the non-keratinized epithelium in the COL area between the papillae follows the shape of the interproximal contact.
Gingiva	Part of the masticatory mucosa that covers the alveolar process and surrounds the cervical portion of the tooth. The gingiva is a fibrous connective tissue covered by keratinized or parakeratinized epithelium, which is continuous in relation to the periodontal ligament and mucosa. The entire gingiva is keratinized (marginal and attached gingiva) except for the soft tissue in the COL region.
Marginal (or free) gingiva	The most coronal portion of the gingiva that surrounds the tooth but is not directly attached in the tooth surface. It includes the soft tissue of the COL area. In a healthy condition, the marginal gingiva forms the wall of the gingival sulcus.
Attached gingiva	Portion of the gingiva that is firm, dense, stippled, and firmly attached to the underlying periosteum and tooth.
Peri-implant keratinized mucosa	Mucosa that extends from the margin of the peri-implant mucosa to the mobile oral lining mucosa and is composed of lamina propria (fibrous connective tissue containing collagen type I and III) covered by squamous orthokeratinized epithelium (Araujo et al., 2017).
Alveolar mucosa (non-keratinized)	Mobile oral lining mucosa. The alveolar mucosa can be stretched and compressed, has a soft texture, and is composed of non-keratinized stratified pavement epithelium and loose connective tissue (Araujo et al., 2017). Coronally, it is separated from the gingiva (or keratinized mucosa) by a junction (or line) called the **mucogingival junction** (Laney et al., 2017).
Peri-implant tissues	Tissues that are located around the implants, divided into hard and soft tissues (Araujo et al., 2017).
Peri-implant hard tissue	Bone tissue in contact with the implant surface. The bone tissue supports the implant (Araujo et al., 2017).
Peri-implant soft tissues	Called “peri-implant mucosa,” formed during the healing process after implant/prosthetic abutment installation (Araujo et al., 2017).
Osseointegration	A direct functional and structural connection between the bone and the implant surface (original definition attributed to Branemark et al., 1985). The phenomenon of bone apposition directly onto the implant surface, which subsequently undergoes structural adaptation.
Medullary bone	Tissue found in the bone marrow, which has a variable trabecular pattern, composed of interstitial tissue that may be hematopoietic (Almas et al., 2018).
Cortical bone	The outer layer of bone tissue, which is dense and known as compact bone (Almas et al., 2018).
Prosthetic abutment	An intermediary component, which connects the prosthesis to the implant, and can receive a screwed or cemented prosthesis. A prosthetic abutment can be titanium, metallic alloy, and ceramic, including zirconia. It can be “stock,” produced by the manufacturer, or personalized. In addition, it can have one or more pieces and be straight or angled (Almas et al., 2018). Note: For some systems, it is still possible to make the prosthesis directly on the implant platform, without using a prosthetic abutment.

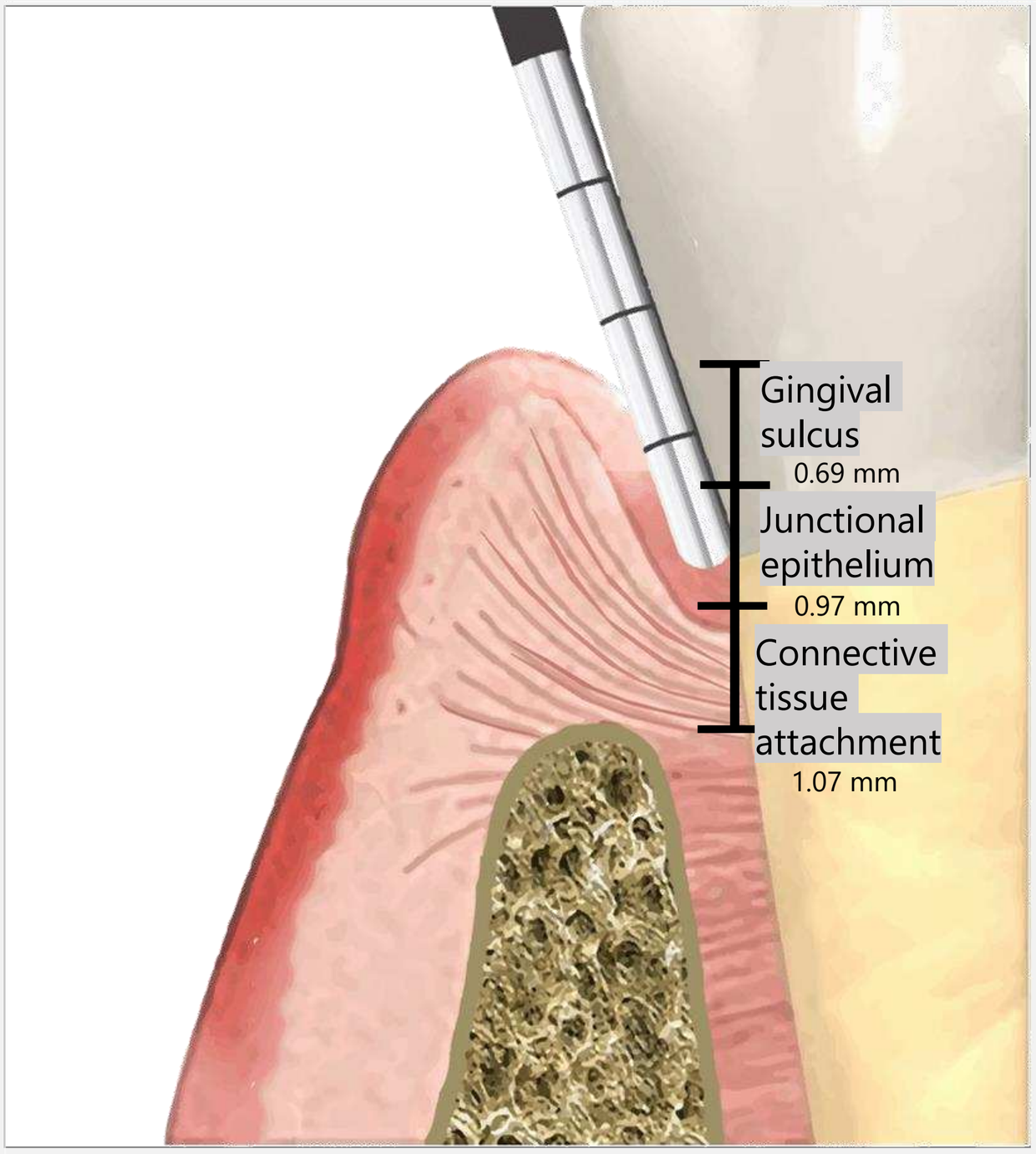
Anatomy of peri-implant tissues

Biological width or Supracrestal Attachment Apparatus

Biological space or supracrestal insertion space: The biological width or supracrestal attachment apparatus exists around teeth and implants (when exposed to the oral cavity). By definition, the term "biological width" does not include the sulcus, however, it will also be addressed in this section for didactic reasons.

On teeth: Periodontal attachment apparatus structure, which measures approximately 3 mm in height in healthy sites. It is composed of the gingival sulcus (0.69 mm on average), the junctional epithelium (0.97 mm on average), and connective tissue attachment (1.07 mm on average) (Gargiulo et al., 1961).

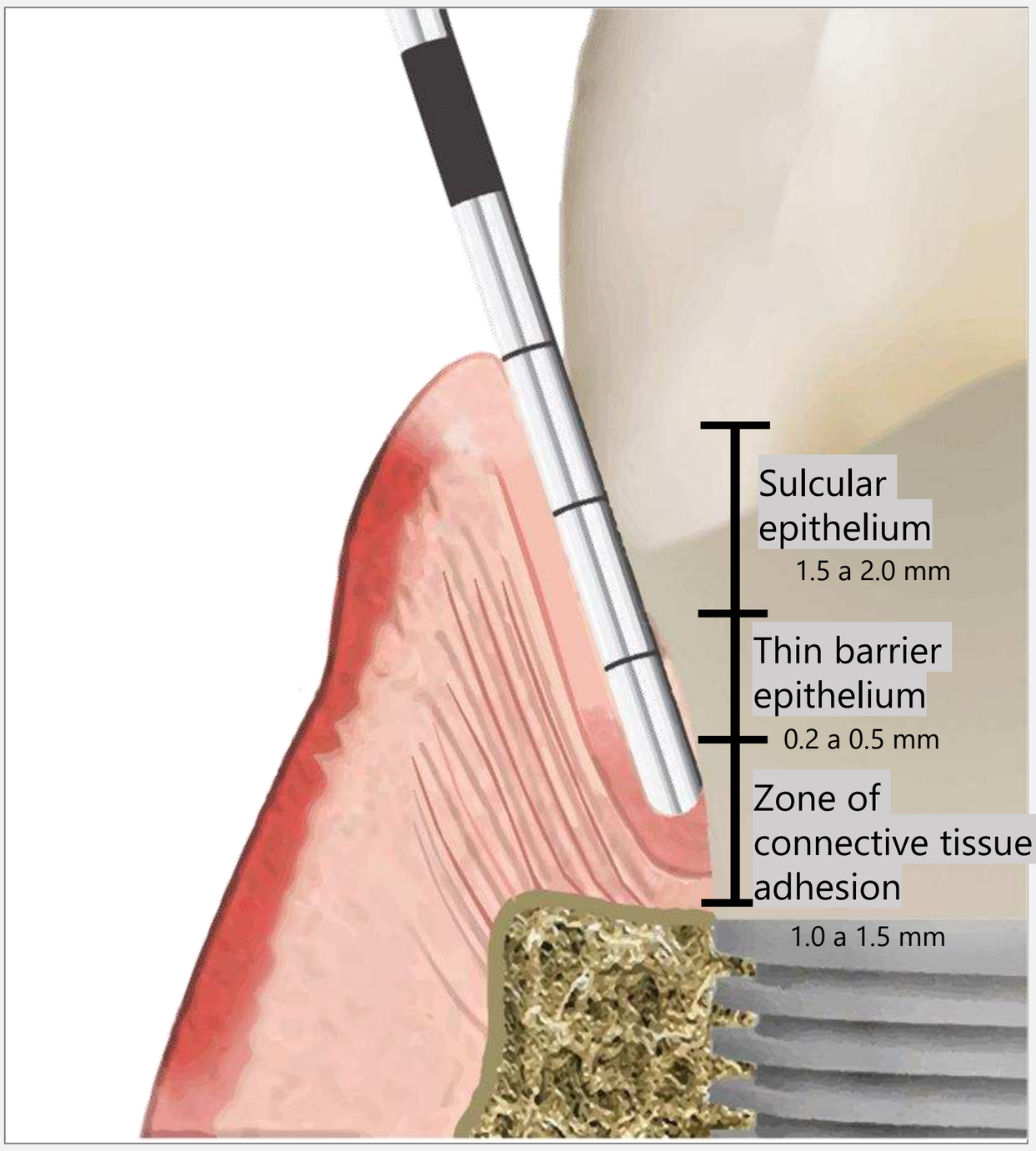
In implants: The inner portion of the peri-implant mucosa with the most significant height variation compared to teeth. It is composed of sulcular epithelium (1.5–2.0 mm), a thin barrier epithelium (0.2–0.5 mm), and a zone of connective tissue adhesion (1–1.5 mm) (Almas et al., 2018).



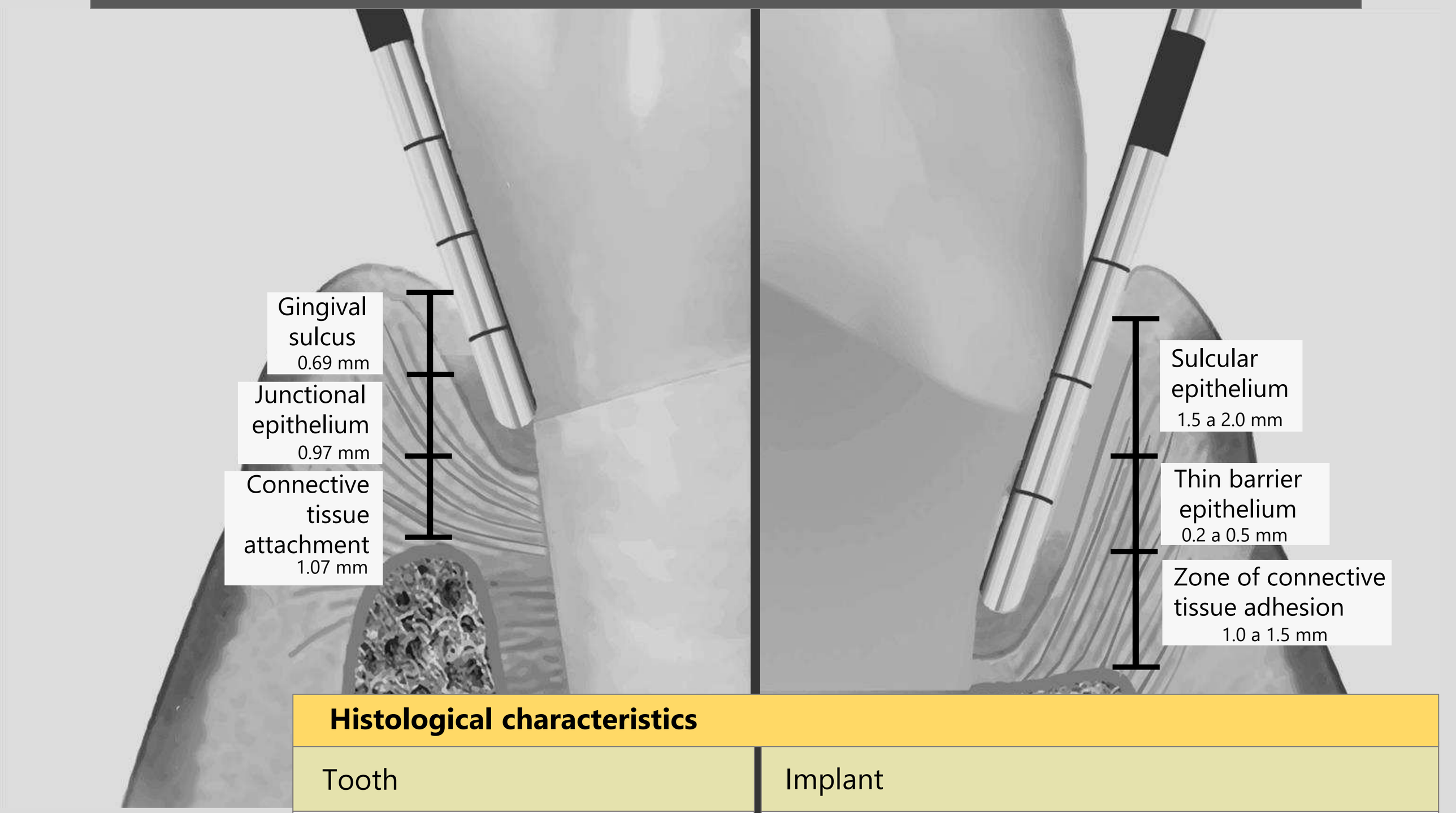
The portion of the peri-implant mucosa that faces the surface of the prosthetic abutment has two distinct portions:

- A more coronal portion - the sulcular epithelium - followed by a more apical portion, surrounded by a thin barrier epithelium (similar to the junctional epithelium of the gingiva).

- A more apical portion, where the connective tissue appears to be in direct contact with the surface of the prosthetic abutment. This apical portion is called the connective tissue adhesion zone (Araujo et al., 2017).



Comparative anatomy of peri-implant tissues



Histological characteristics		
	Tooth	Implant
Periodontal ligament	Presence of periodontal ligament	Absence of periodontal ligament
Oral epithelium	Keratinized and continuous with the sulcus epithelium	Keratinized and connects to the epithelial barrier
Junctional/sulcular epithelium	1-3 mm	≤5.0 mm (healthy state)
Permeability of the epithelium	Less permeable (Ikeda, et al., 2002).	More permeable (Ikeda, et al., 2002).
Interface with the alveolar bone	Presence of a periodontal ligament	Absence of periodontal ligament
Vascularization	Larger, supraperiosteal, and by the periodontal ligament	Minor and periosteal
Collagen fibers	The periodontal collagen fibers are perpendicular/oblique to the root surface and inserted into the root cementum (Sharpey's fibers)	The peri-implant collagen fibers are in a parallel direction to the implant's surface or prosthetic pillar, and are not attached in the implant and/or circumferentially arranged in the peri-implant mucosa.
Fibroblasts	The periodontal connective tissue has a higher number of fibroblasts and fewer collagen fibers (Moon et al., 1999).	The peri-implant connective tissue presents a lower number of fibroblasts and a higher amount of collagen fibers, being comparable to a scar tissue (Moon et al., 1999).

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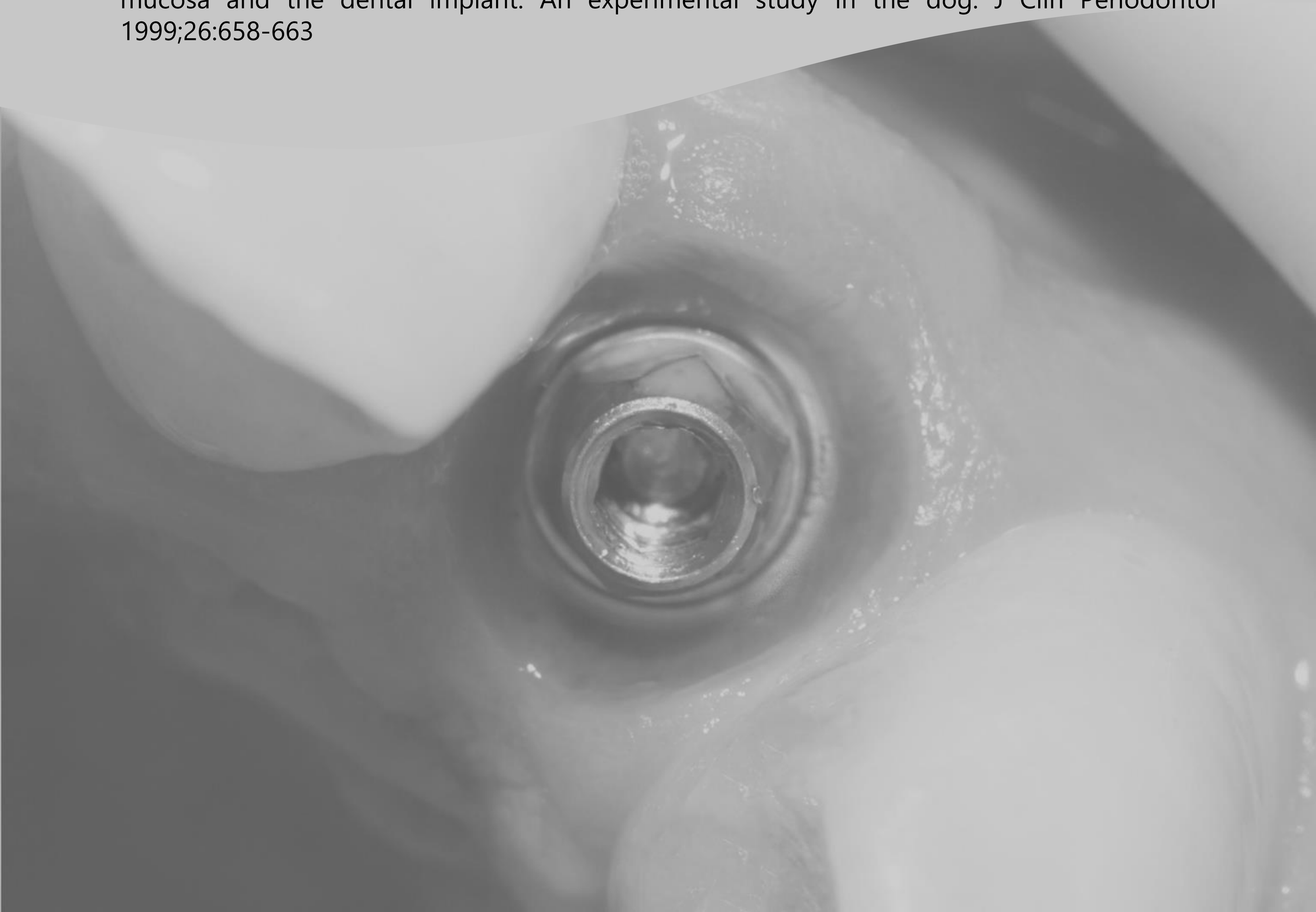

CHAPTER 02

Clinical examination of peri-implant tissues

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Figure: Bill Okuma

Clinical examination of peri-implant tissues

Why perform?	Examination of the peri-implant tissues is essential for diagnosing peri-implant health or disease and monitoring these conditions over time. This examination includes **visual inspection, peri-implant probing,** and **digital palpation**.
	The **probing** of peri-implant tissues aims to assess the distance from the base of the peri-implant sulcus or pocket to the peri-implant mucosa margin, enabling the evaluation of bleeding on probing, suppuration, and changes in the position of the peri-implant mucosal margin (Berglundh et al., 2018).
When to perform?	The clinical evaluation should be performed periodically, like natural teeth, at least once a year (Renvert et al., 2018). The recommended interval is every 6 months (Monje et al., 2016).
What to evaluate?	**1. SIGNS OF INFLAMMATION:** The presence or absence of signs of peri-implant inflammation can be verified by visual inspection. The following should be observed: 1. Tissue coloration (pink or red); 2. presence or absence of swelling; and 3. consistency of the peri-implant tissues, which may be firm or not (Renvert et al., 2018). **2. CLINICAL PROBING DEPTH (PD):** Distance from the peri-implant mucosal margin to the bottom of the peri-implant sulcus or pocket during peri-implant probing (Laney, 2017, Almas et al., 2018). **3. CLINICAL ATTACHMENT LEVEL (CAL):** Distance from the implant collar (implant-prosthetic abutment interface) to the bottom of the peri-implant sulcus or pocket during peri-implant probing (Almas et al., 2018; Laney, 2017). **4. BLEEDING ON PROBING (BOP):** Bleeding on probing that occurs simultaneously with inflammatory tissue changes at the probing site. Caution: Bleeding from a site may occur due to traumatic injury during probing. It should not be considered in the absence of other inflammatory changes (Renvert et al., 2018). **5. SUPPURATION:** It can be visualized on clinical examination after palpation under light tissue pressure or peri-implant probing. It is associated with acute or chronic infection (Almas et al., 2018; Laney, 2017; Renvert et al., 2018).

Figure: Isabella Reis

Clinical examination of peri-implant tissues

Clinical attachment level (CAL): calculated as the sum of the distance from the implant collar to the gingival margin (recession, positive value, or when there is soft tissue above the implant collar, negative value) + PD.

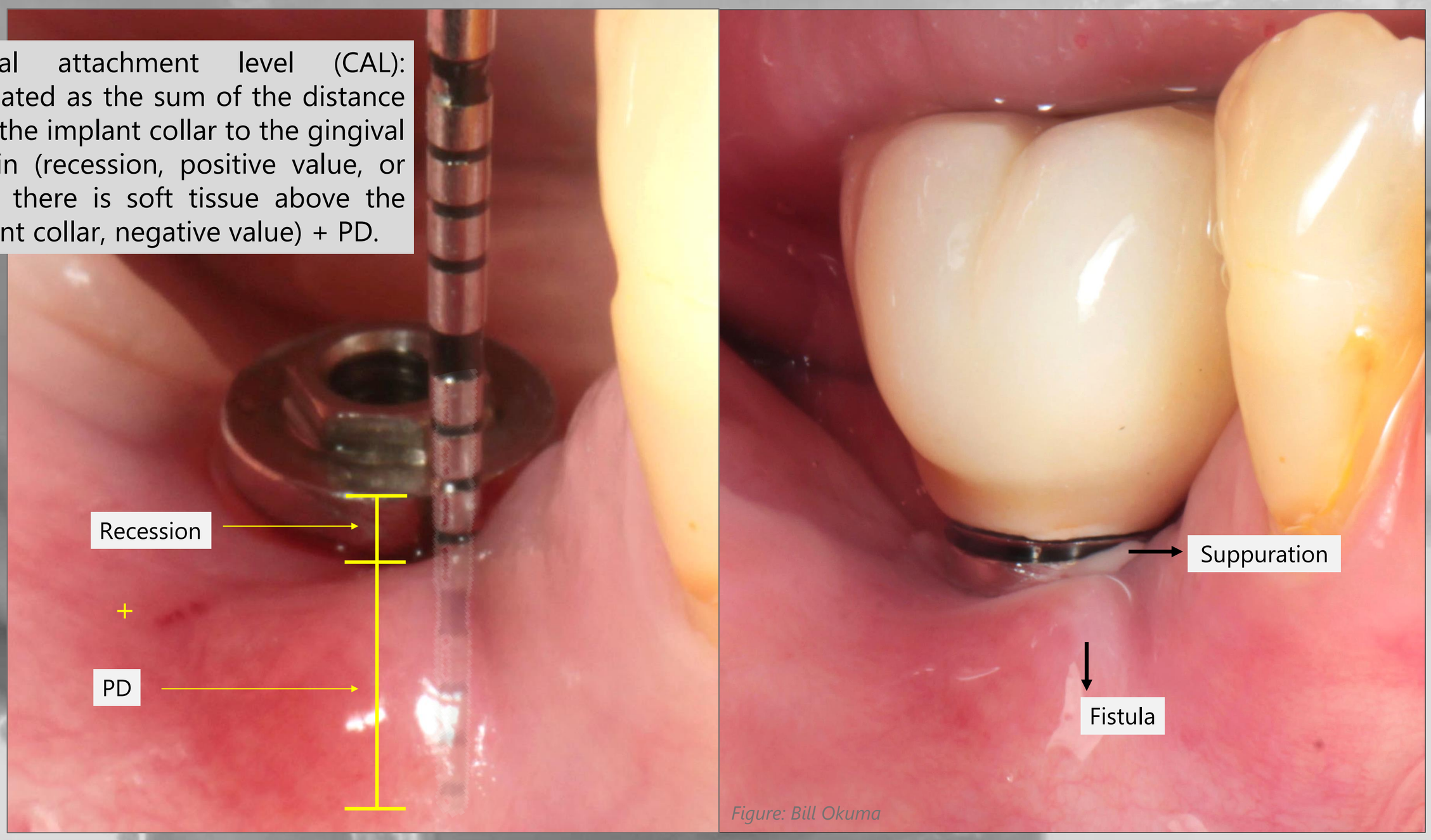


Figure: Bill Okuma

1. VISUAL INSPECTION: Clinical visual analysis of the characteristics of peri-implant tissues.

2. PERI-IMPLANT PROBING

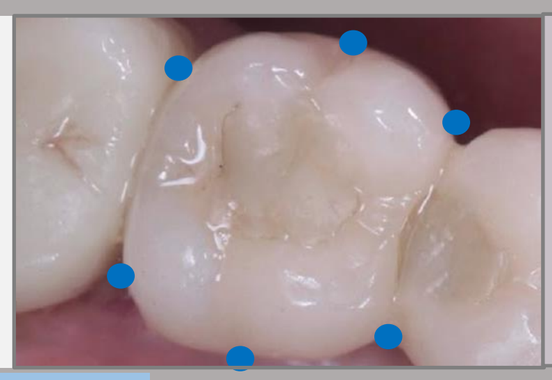
Instrumental used:

North Carolina Metallic Probe 15 mm

Plastic Millimeter Probe 12 mm

How to examine?

Plastic probe × metal probe: To date, there is no evidence of the superiority of one probe over the other in performing the peri-implant clinical examination; therefore, both can be used. The access may be easier using the plastic probe in some situations.
It is essential to standardize the measurement so that the same periodontal probe is used at each examination of the same implant throughout the follow-up period to avoid discrepancies.



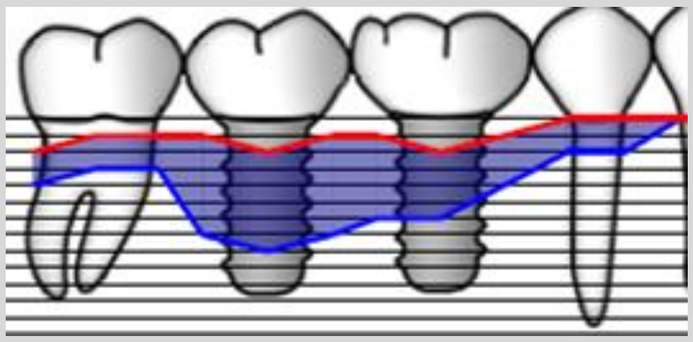
Probing of the six sites, circumferential with light force (~0,25 N).
(Almas et al., 2018)

3. DIGITAL PALPATION: Gently palpate each peri-implant site, groping from the apical region of the implant to the margin of the peri-implant mucosa with the tip of the index finger to check for signs of inflammation, such as bleeding or suppuration.

Clinical examination of peri-implant tissues

How to register?

Periogram



PM - IC	2 1 1	* 1 2 1 *	1 2 1	0 0 0
PD	● 2 2 ● 2	● 6 6 ● 6	● 5 4 ● 3	2 2 2
CAL	4 3 3	7 8 7	6 6 3	2 2 2

- PM – IC: Distance from the peri-implant mucosa margin to the implant collar
- PD: Clinical probing depth
- CAL: Clinical Attachment Level
- Bleeding on probing: ●
- Suppuration: *

To access the Periodontal Chart, for clinical use, simply scan this QR code.

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CHAPTER 03

Radiographic examination of peri-implant tissues

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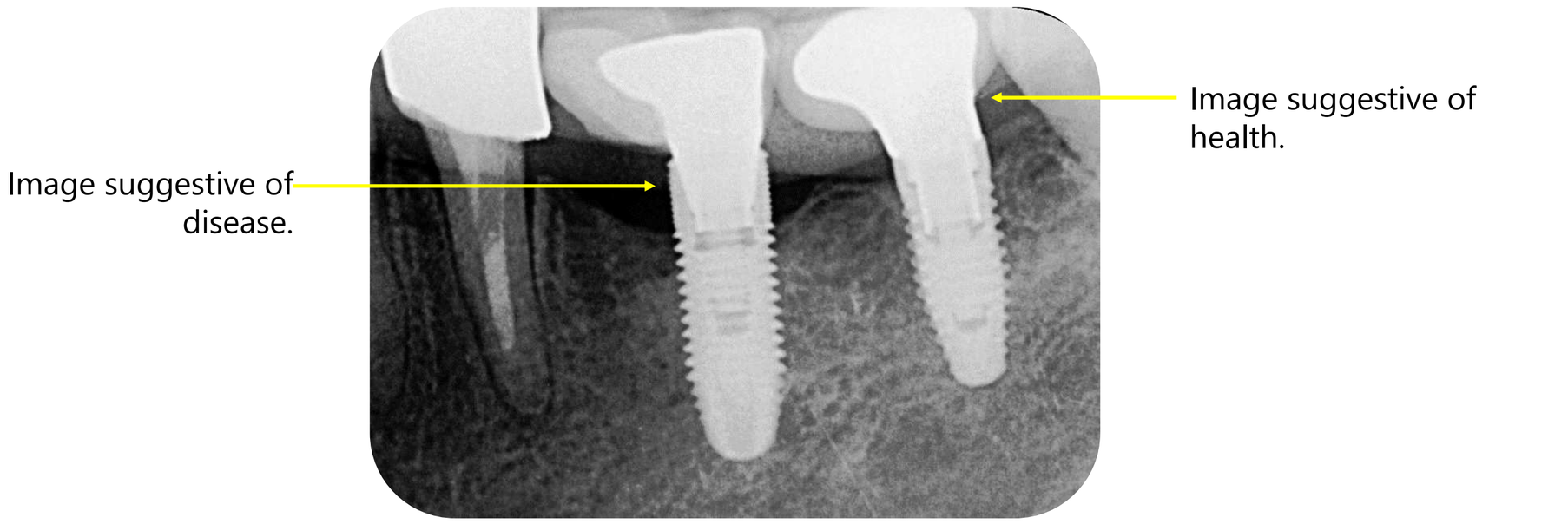
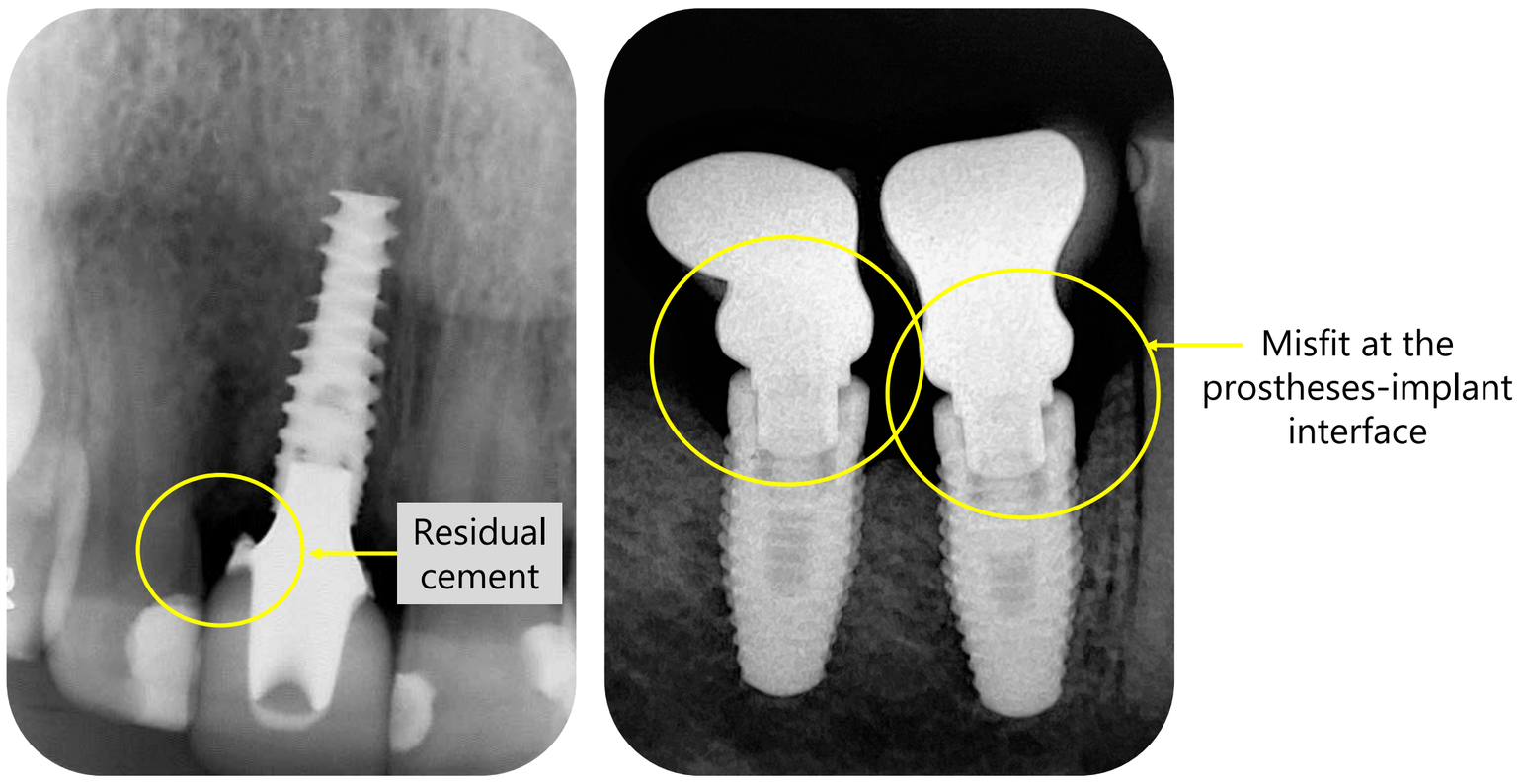
Radiographic examination of peri-implant tissues

- **Mesial and distal radiographic bone levels**, assessed in parallel periapical and/or vertical bite wing radiographs, are fundamental parameters for diagnosing peri-implant diseases and conditions. When evaluated together with the clinical findings, they are determinants for establishing the correct diagnosis.
- NOTE: The panoramic radiograph is not useful for evaluating the peri-implant bone radiographic levels. The lack of detail of the anatomy of the bone tissue, uneven magnification, and geometric distortion that can occur are some of the reasons why it is not indicated for this purpose.



Why perform?

- In the case of health, periapical radiographs will be used as parameters for monitoring peri-implant health over time. In the case of disease, they are essential to classify it and evaluate stability or progression over time, prognosis, and therapeutic decision-making.
- In the case of cemented prostheses, residual cement from cemented prostheses can be identified on periapical radiographs. Residual cement is considered a risk factor for peri-implant diseases.
- Radiographic examination can evaluate possible biomechanical complications, resulting in biological complications such as peri-implant mucositis and peri-implantitis. Some examples are fracture of components and/or the implant itself, possible mismatches between the implant and the prosthetic pillar, or between the prosthetic pillar and the margins of the prosthetic restoration.



Radiographic examination of peri-implant tissues

When to perform?

1) **At the time of implant placement**. The mesial and distal bone level measurements from this initial radiograph will reference future reevaluation (Berglundh et al., 2018; Renvert et al., 2018).

2) At **follow-up visits after the prosthesis installation** to establish a reference of the bone level after the initial physiological remodeling (Renvert et al., 2018)

3) In the **presence of signs of peri-implant inflammation** (redness, swelling, bleeding on probing, and/or suppuration. (Renvert et al., 2018).

NOTE: In cases of early and immediate implant placement, the first radiograph should be taken at implant installation to record the bone loss that occurs during the initial remodeling period (De Bruyn et al., 2013).

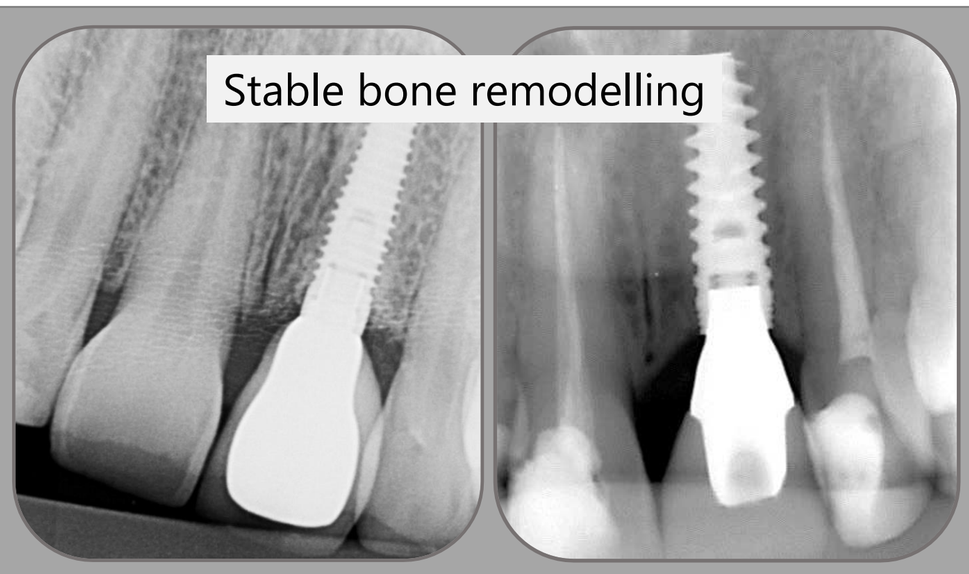
What to evaluate?

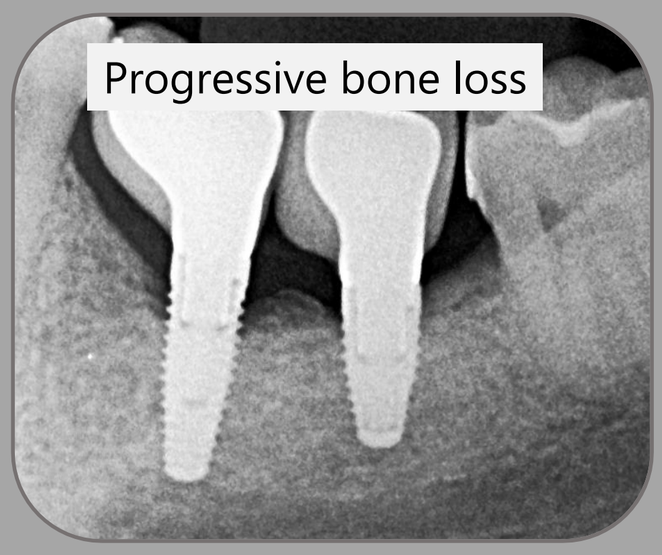
Changes in interproximal bone levels should be assessed.

Albrektsson and Isidor (1994) suggest that a level of bone resorption less than 1.5 mm is acceptable in the first year after implant installation, and 0.2 mm in the years thereafter (Albrektsson & Isidor, 1994). This concept was developed from Branemark's original implant observations. Over the years, implants have evolved, mainly in the design and surface properties, so that greater bone stability can be expected. Therefore, with modern implant designs, and that this loss was even smaller than the proposed one. However, in general, an initial loss of 0.5 to 2 mm is expected after implant and prosthesis installation due to the initial healing process of the implant (Renvert et al., 2017).

Understanding different patterns of bone loss is critical in the diagnosis of health and disease:

- **Early bone loss:** Bone resorption around the implant neck, from its installation until 1 year after installing the prosthesis. Often this is described in the literature as "saucerization" or "saucer-shaped", meaning that the bone loss occurs in a circumferential pattern. This type of bone loss is historically considered both natural and inevitable, and results from biological remodeling, particularly at implants with a smooth collar design..
- **Stable bone remodeling or bone loss:** Presence of some bone loss that does not progress and stops after some time when the implant is in function (installed prosthesis). This type of bone loss may be caused by biological or mechanical factors.
- **Progressive bone loss:** A pathological condition of bone loss in progress. It is not possible to predict whether this loss will stop or continue. It can lead to biological, esthetic, and functional problems, and even implant loss if it continues. Peri-implantitis is an inflammatory disease of the peri-implant mucosa, with progressive bone loss beyond initial bone remodeling.





Radiographic examination of peri-implant tissues

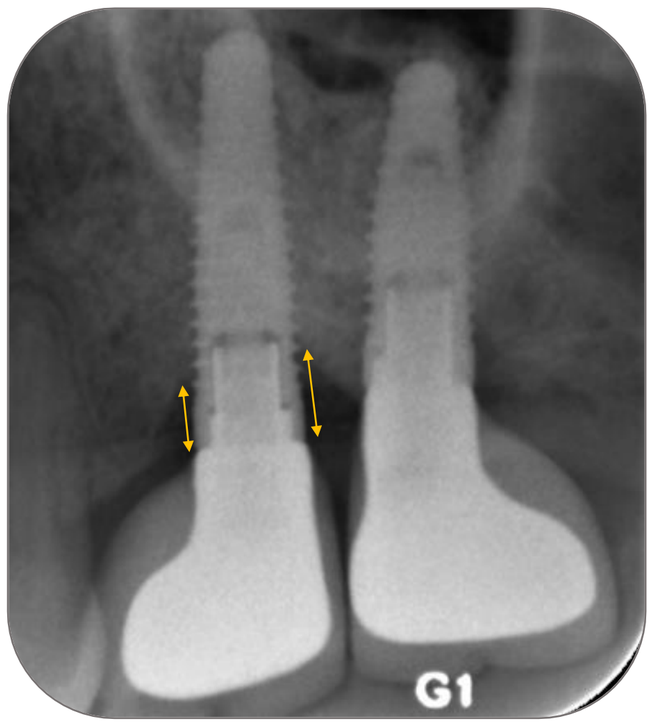
How to get and analyse the image?

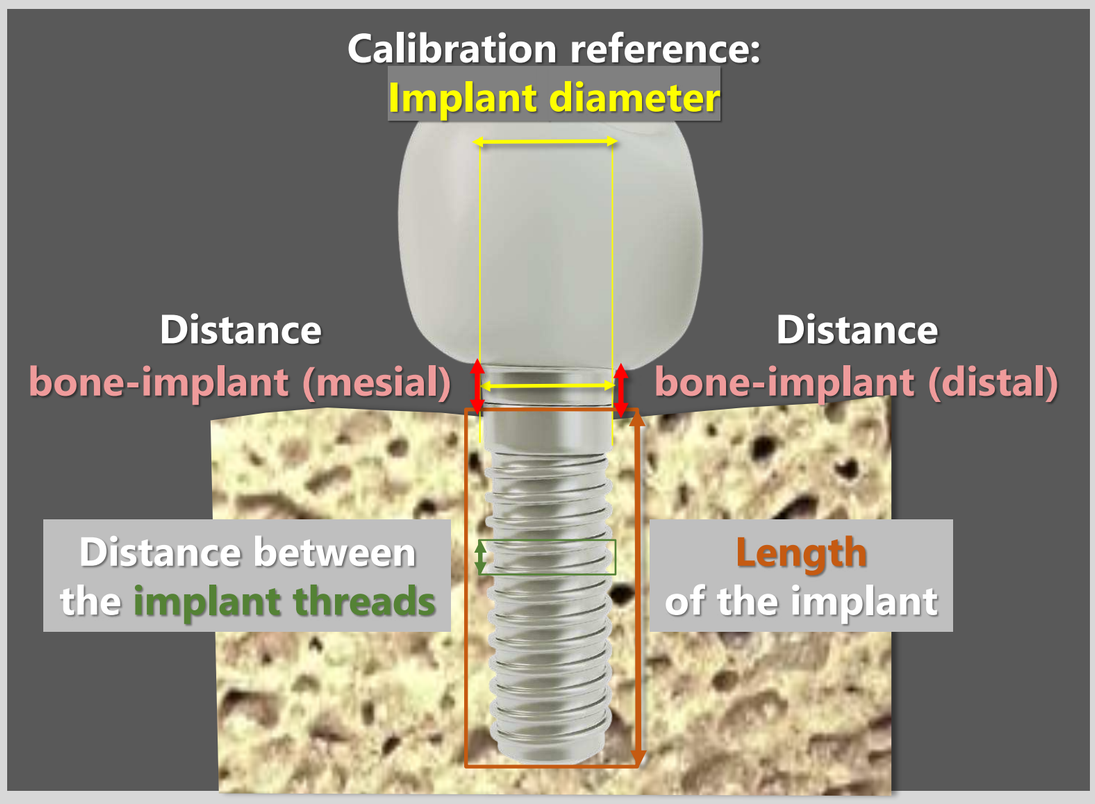
PARALLELISM TECHNIQUE

- Easier standardization.
- Results in less image distortion.

OBTAINING THE MEASUREMENTS:

- On radiographs, marginal bone level measurements are taken using a reference point on the implant. (Burtscher et al., 2015).
- The amount of bone loss is measured at the mesial and distal sites of each implant (Burtscher et al., 2015).
- The reference point is the prosthetic-implant interface. Calibration of the measurement can be performed using already known measurements, such as the diameter and/or length of the implant in question, as well as the distance between implant threads. (Burtscher et al., 2015).

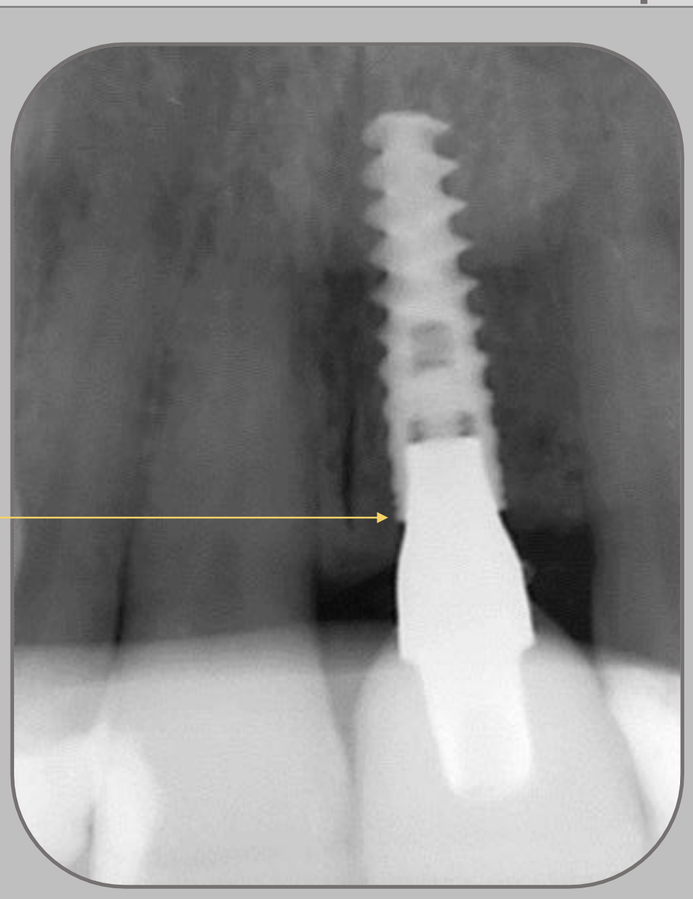




Adapted from: Burtscher et al., 2015

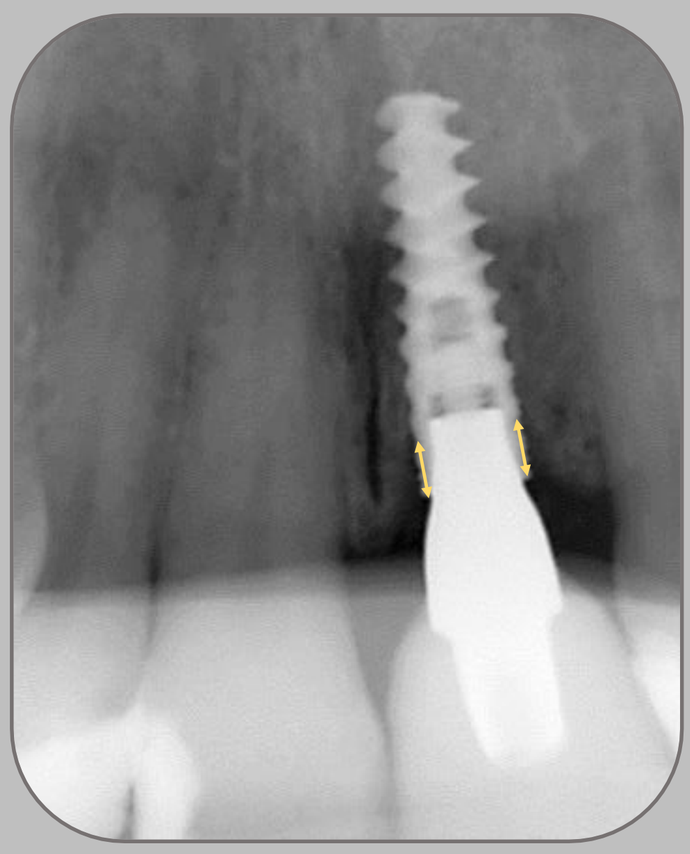
Radiograph performed on the day of prosthesis installation.

Bone is observed at the same level as the abutment-implant interface.



Radiograph performed 1 year after prosthesis installation.

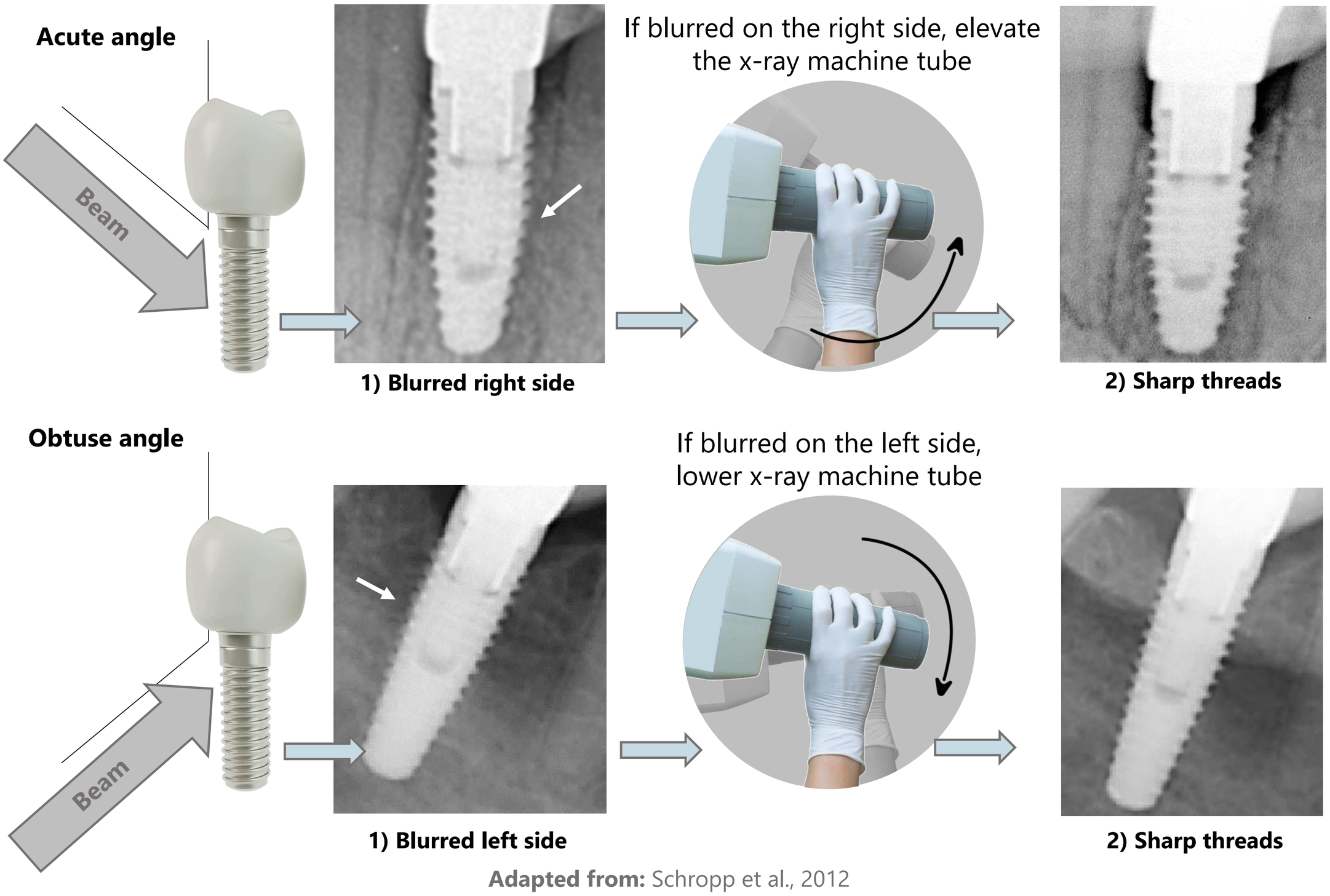
Bone loss is observed in relation to the bone level verified in the previous time (day of prosthesis installation), considering the same reference (abutment-implant interface).



Radiographic examination of peri-implant tissues

Suggestion for obtaining the image:

- An optimal projection angle in the vertical plane is required to obtain implant radiography with sharp spirals and without overlaps on both sides. This is achieved when the film (phosphor plate or digital sensor) is parallel to the implant, and the X-ray beam is directed perpendicular to its long axis (Schropp et al., 2012).
- Standardizing the projection angle is also important to compare the bone level in radiographs of the same implant taken at different times. The RB-RB/LB rule (If Right Blur then Raise Beam [RB-RB]; Left Blur then Lower Beam [LB-LB]) can be used for this purpose (Grondahlet al. 1996):
    - If the implant threads are blurred on their right side in the X-ray image, the direction of the X-ray beam should be raised toward the ceiling to obtain a sharper image of threads on both sides of the implant.
    - Similarly, if the implant threads are blurred on the left side of the implant, the direction of the X-ray beams should be lowered toward the floor to obtain an image with sharp spines on both sides of the implant (Grondahl et al. 1996).



Adapted from: Schropp et al., 2012

Why does this happen?

The rule is based on the fact that implants are inserted by rotating clockwise; thus, implant threads appearing blurred mainly on the right or left side of the implant indicate that the beam angle was acute or obtuse, respectively, concerning the long axis of the implant (Grondahl et al., 1996).

Computed tomography

When and why perform?

- Two-dimensional radiographs (periapical and panoramic radiographs) have limitations as they do not allow assessment and distinction of the buccal and lingual/palatal alveolar bone levels. (Misch et al., 2008, Lindhe et al., 2018).
- In contrast, three-dimensional computerized tomography (CBCT) images allow visualization of different orthogonal planes on the peri-implant hard tissues (Misch et al., 2008, Lindhe et al., 2018, Kühl et al., 2016).
- Thus, CBCT can be used as an additional examination, in special circumstances, such as to examine the three-dimensional bone structure in cases where the prognosis of the implant is doubtful or planning minimally invasive therapeutic approaches when some peri-implant disease or condition is already present (Monje et al., 2019).
- CBCT should not be used as a standard for assessing peri-implant defects. Issues such as the higher radiation dose and cost-efficiency of this examination should be considered in decision making (Kühl et al., 2016, Monje et al., 2019).

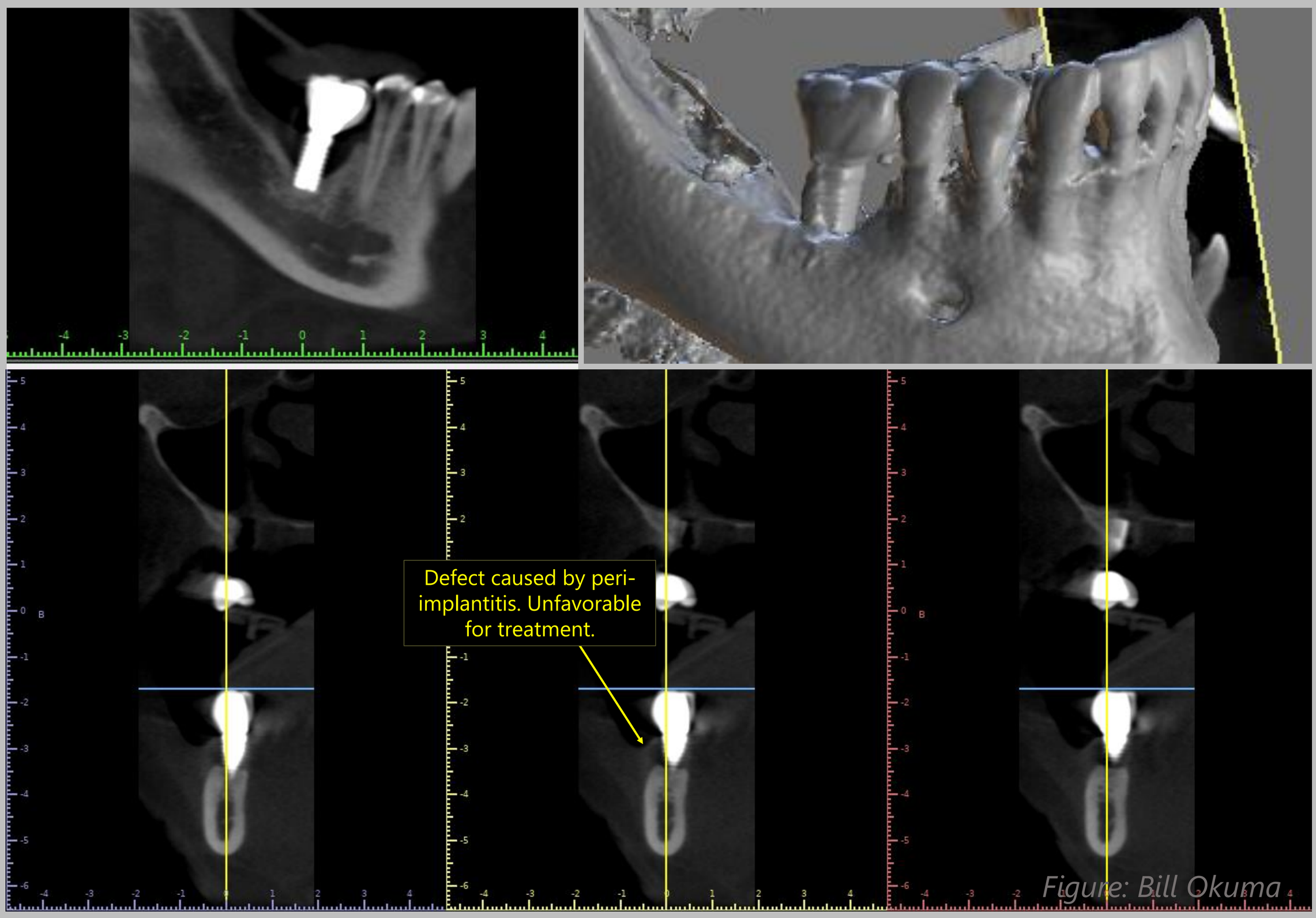


Figure: Bill Okuma

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CHAPTER 04

Risk indicators for peri-implant diseases

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Figure: Isabella Reis

Risk indicators and factors for peri-implant diseases

Like periodontitis, peri-implantitis has been associated with inadequate dental biofilm control. However, the anatomical, histological, and microbiological differences between periodontal and peri-implant tissues appear to cause the **onset and progression of peri-implant diseases to occur differently than those of periodontal diseases** (Coli et al., 2017, Lee & Ivanosvisk, 2018). Although implants share standard features with teeth, such as a junctional epithelium and a connective tissue component, there are some crucial differences. The contact between the connective tissue and the implant surface, where collagen fibers are "adapted" in a parallel arrangement concerning the implant, combined with reduced cellularity and vascularity in the peri-implant connective tissue, may contribute to disease establishment.

Periodontitis, in turn, has structures that serve as "obstacles," such as the oblique/perpendicular attachment fibers connected to the root cementum (Ivanosvisk & Lee, 2018). Furthermore, implant surface energy, topography, hydrophilicity, and electrochemical loadings of the substrates affect biofilm adhesion and constitution, and consequently, the response of defense cells such as macrophages. There are also differences concerning the microbiome between periodontitis and peri-implant diseases (Kotsakis & Olmedo, 2021, Yu et al., 2019). The presence of a subgingival connection between the implant and the abutment and/or crown is also a challenge, and different prosthetic connections allow bacteria to pass through in different amounts (Lee & Ivanosvisk, 2018).

Furthermore, just as there are risk factors and indicators for periodontal diseases, some factors can influence the onset and progression of peri-implant disease. Individual and implant-related aspects, such as a history of periodontal disease, percentage of sites with bleeding on probing, presence of PD > 5 mm, supportive periodontal therapy, bone loss due to aging, and prosthetic aspects, need to be analyzed individually in the maintenance phases (Heitz-Mayfield et al., 2020).

Risk indicators for peri-implant diseases

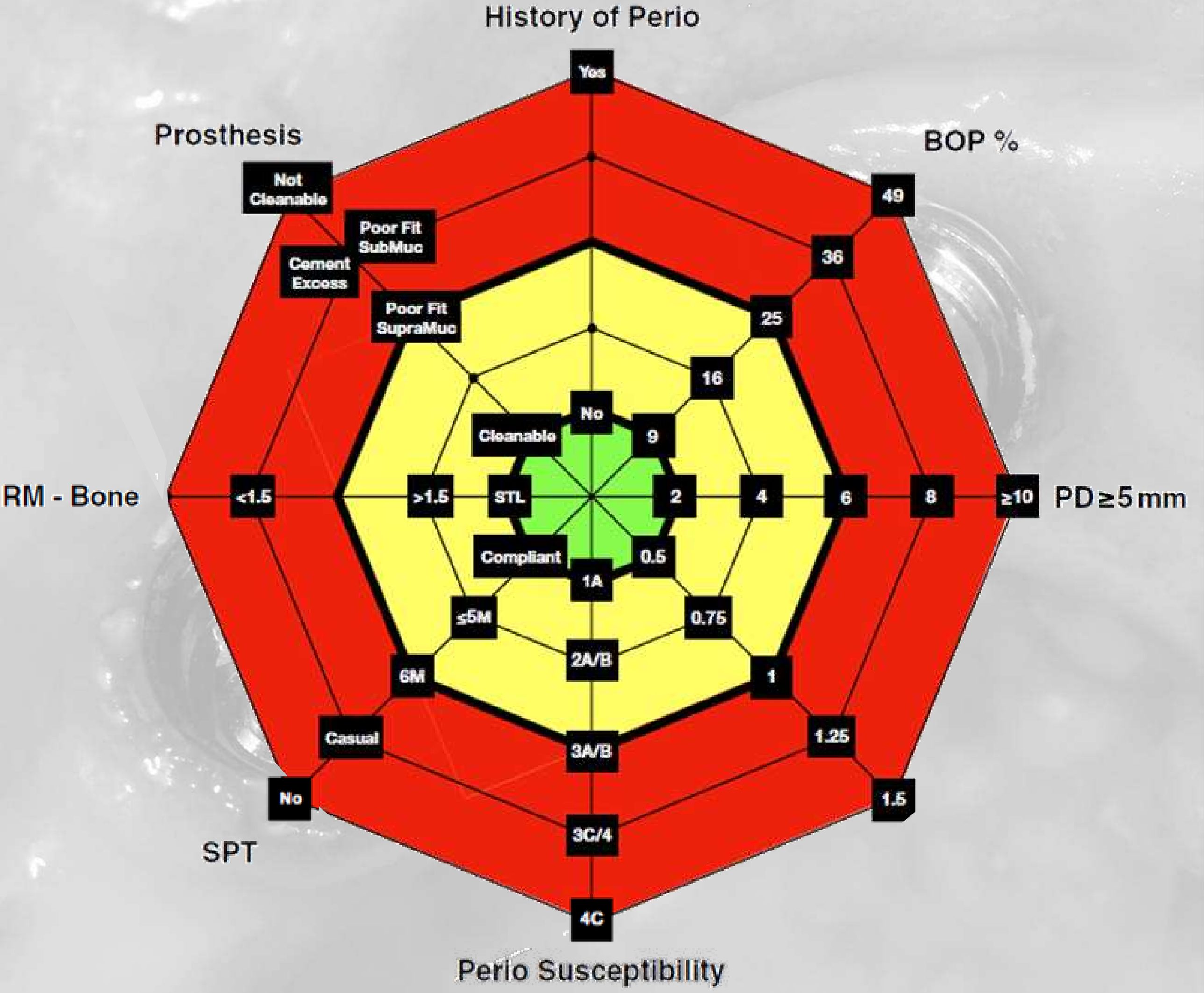
During periodontal and peri-implant maintenance visits, a risk assessment can be performed to evaluate the risk of developing peri-implantitis. The risk assessment should consider both patient- and implant-related aspects.

In 2020, Dr. Lisa Heitz-Mayfield and colleagues developed a tool for assessing the risk of developing peri-implantitis; this is explored below (Implant Disease Risk Assessment [IDRA] functional diagram, which was adapted from previous risk-assessment tools for periodontitis. (Lang and Tonetti, 2003).

Eight parameters were identified as risk indicators for the development of peri-implant disease:

1. History of periodontitis	Patients with a history of periodontitis or tooth loss due to periodontitis are at higher risk of developing peri-implantitis. (Derks et al., 2016; Kordbacheh Changi, Finkelstein, & Papapanou, 2019; Roccuzzo, De, Angelis, Bonino, & Aglietta, 2010).
2. Percentage of sites with bleeding on probing (BOP%)	Patients with %BOP (< 10%) are at low risk of developing peri-implantitis (Lang, Adler, Joss & Nyman, 1990), while patients with %BOP > 25% are at high risk.
3. Prevalence of probing depth (PD) ≥ 5 mm	An increased presence of sites with periodontal pockets (PCS ≥ 5mm) and increased PCS during supportive periodontal therapy is noted (Cho-Yan Lee, Mattheos, Nixon, & Ivanovski, 2012, Pjetursson et al., 2012).
4. Periodontal bone loss with age (BL/Age)	Estimation of alveolar bone loss is performed either on periapical radiographs, where the worst site of the most affected tooth is estimated as the % of the root length, or on bitewing radiographs, where the worst affected site is estimated in mm. In bitewing radiographs, 1 mm is considered equal to 10% bone loss (Derks et al., 2016, Kordbacheh Changi et al., 2019).
5. Susceptibility to periodontitis, as reviewed by the Classification of Periodontal and Peri-implant Diseases Workshop (Tonetti, Greenwell & Kornman, 2018).	**Stage 1 grade A** represents **low risk**; **Stage 2** represents **moderate-high risk**; **Stage 3** represents **moderate-high risk**; and **Stage 4** represents a **high risk**. Regarding grade classification, Grade B represents a moderate-high risk, and grade C represents a high risk.
6. Support periodontal therapy (SPT)	Regularly performed maintenance consultations are extremely important for peri-implant health and stability (Costa et al., 2012; Monje et al., 2016; Roccuzzo, Bonino, Aglietta, & Dalmasso, 2012). An interval between maintenance visits of ≤ 5 months is considered appropriate for maintaining peri-implant health (Monje et al., 2016).
7. Depth of the prosthesis on implant (RM – Bone)	Refers to the **distance from the margin of the prosthesis to the bone**. Low risk for a tissue level implant, moderate risk when the distance is 1.5 mm, and high risk when the distance is < 1.5 mm.
8. Factors related to a prosthesis	The prosthesis design can make cleaning difficult, as well as its misfit and cement excess might favor biological complications.

The diagram is composed of the **eight parameters** (in vector form) and must be filled in to assess the patient's risk of developing peri-implantitis.



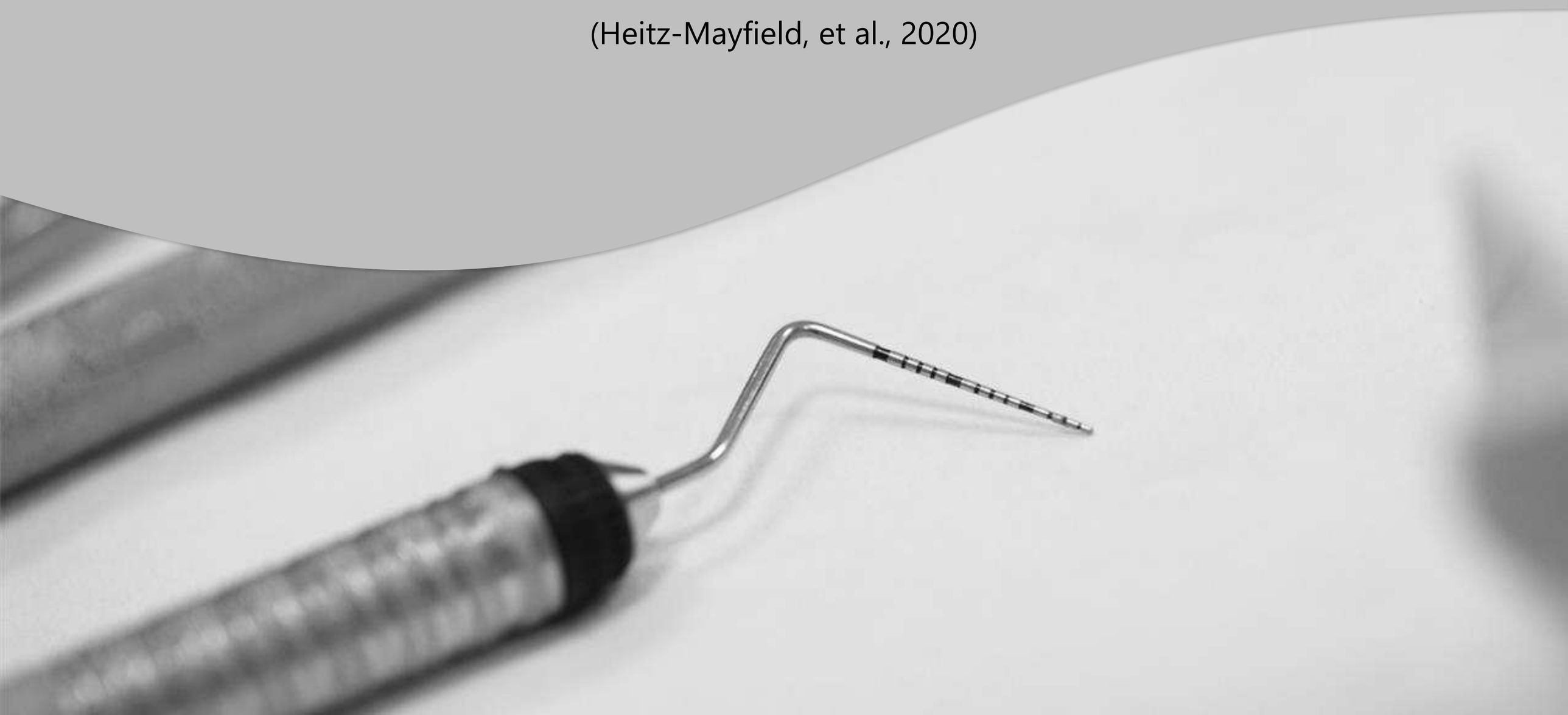
(Heitz-Mayfield, et al., 2020)

To access the diagram (online), for clinical use, simply scan this QR code.

How to use the diagram:

- A patient with low IDRA has all of the parameters in the low-risk categories or at most one parameter in the moderate risk category.
- A patient with moderate IDRA has at least two parameters in the moderate risk category, but at most, one parameter in the high-risk category. A moderate IDRA patient may also have one parameter in the high-risk category and all other parameters in the low-risk category.
- A patient with high-risk IDRA has at least two parameters in the high-risk category.
- In a high-risk patient with a high % SS and a high number of residual pockets (PS ≥ 5 mm), the risk of developing peri-implant disease can be reduced to a moderate IDRA category if additional successful periodontal therapy is provided.
- Aspects related to the prosthetic implant can also be modified, for example, by replacing the prosthesis.
- The history of periodontitis is a factor that cannot be modified. Compensation for this high risk can be obtained by minimizing the effect of the other parameters.
- In a patient whose history of periodontitis cannot be determined, this parameter is not assigned. Furthermore, in a fully edentulous patient, assigning the parameter bone loss/age is impossible.
- If a patient has a history of peri-implantitis, the risk assessment for the parameter “history of periodontitis” should be assigned as high.
- The frequency of control and maintenance visits should be chosen considering the patient’s risk, and patients at high and moderate risk should be evaluated more frequently.

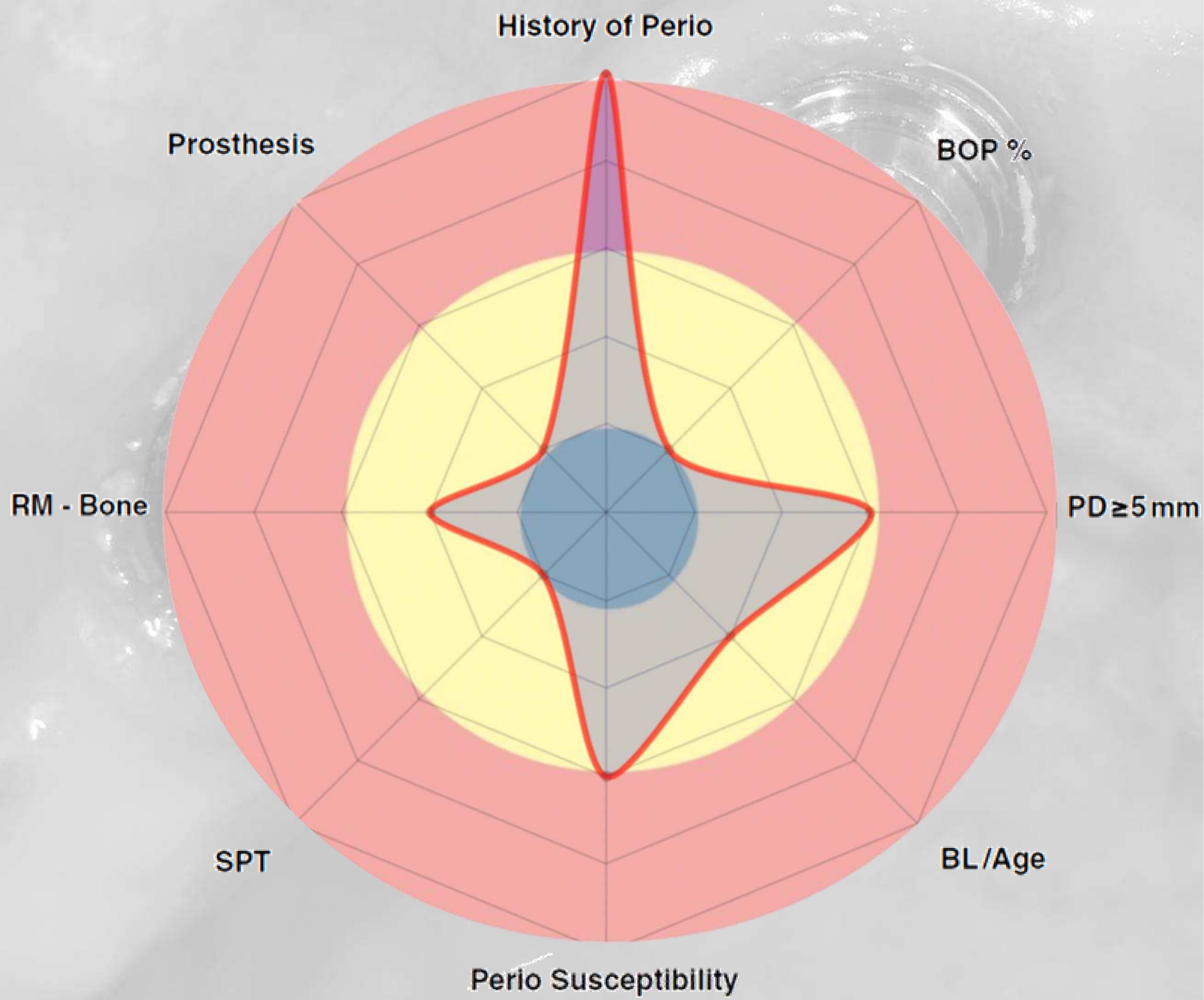
(Heitz-Mayfield, et al., 2020)



How to use the diagram:

Clinical case example:

45-year-old patient - Number of implants = 6; Number of teeth = 22 - History of periodontitis, 9% BOP, number of siTes with PD ≥ 5, Bone loss / Age = 0.8, Susceptibility to periodontitis = 3A/B, Collaborating SPT, Prosthesis depth 1.4, Hygienizable prosthesis.



Individual risk: <u>Moderate</u>

(Heitz-Mayfield, et al., 2020)

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CHAPTER 05

Peri-implant health

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Figure: Isabella Reis

Peri-implant health

1. What are the clinical and radiographic parameters of peri-implant health?

1. **VISUAL INSPECTION**: No clinical signs of inflammation (absence of redness and swelling).
2. **PERI-IMPLANT PROBING:** Absence of bleeding on probing and/or suppuration and increased PD concerning PCS on the day of prosthesis installation.

NOTE: In contrast to the periodontal parameters, when examining the peri-implant tissues, it is <u>impossible to define a range of probing depth that is compatible with health.</u>

- There is an association between PCS ≤ 5.0 mm and peri-implant health. However, this parameter should not be considered in isolation. It is possible that peri-implant health can exist with PCS > 5. Clinical signs of inflammation and bleeding on probing are more important and determinant in the diagnostic process.
- The probing should be performed by applying light force to avoid bleeding by tissue injury induction.

3. DIGITAL PALPATION: Absence of suppuration.

4. RADIOGRAPHIC EVALUATION: Bone loss ≤ 2 mm at any time during or after the first year of denture installation (first year in function). Or, in the absence of the periapical radiograph from the date of denture installation, radiographic evidence of bone loss < 3 mm.

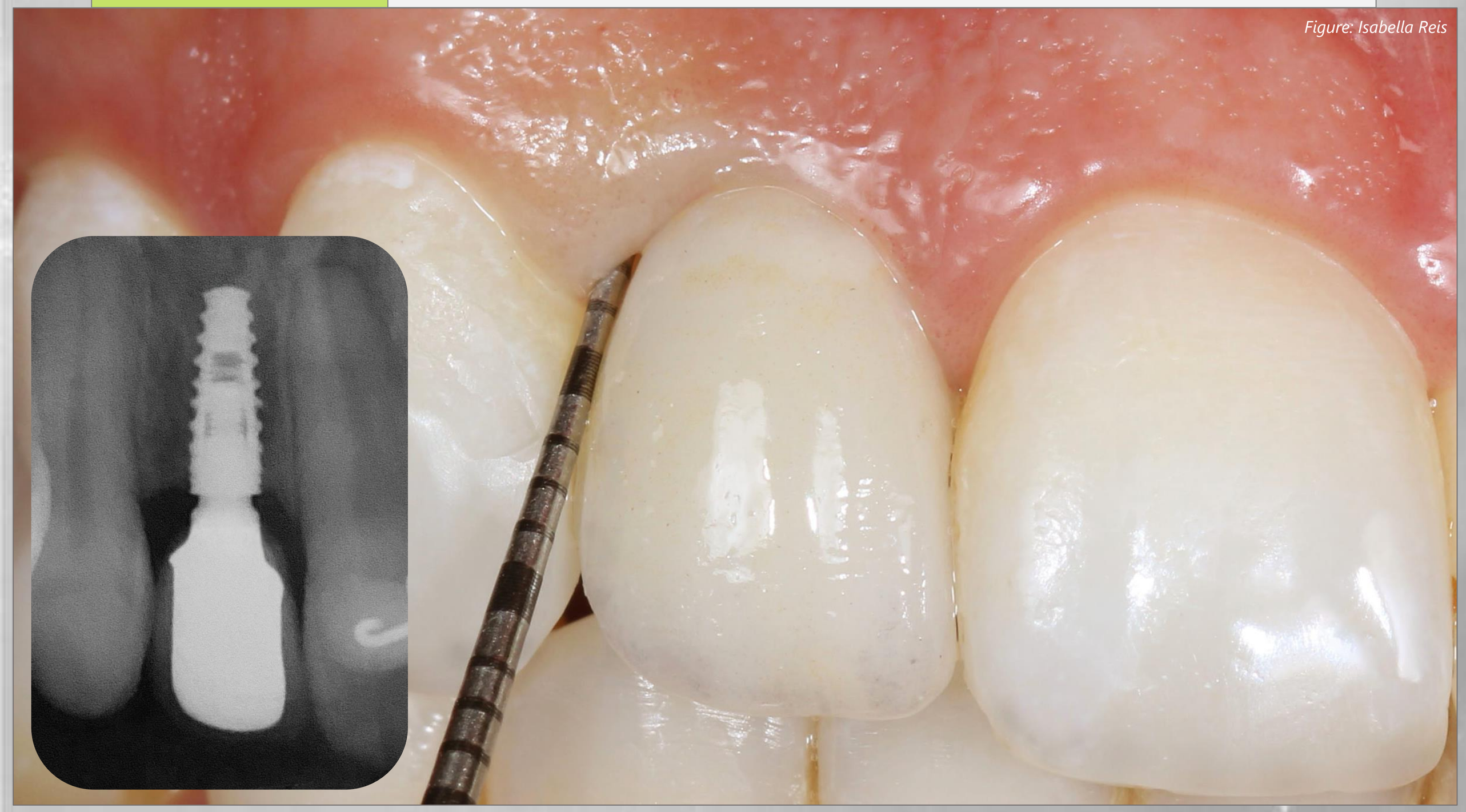

Figure: Isabella Reis

Peri-implant health

2. What are the diferences between periodontal and peri-implant health?	**Clinical and radiographic examination**	**PERIODONTAL HEALTH**	**PERI-IMPLANT HEALTH**
	Visual inspection	Absence of redness and swelling.	
	Probing	Absence of bleeding and/or suppuration on probing.	
		PD from 1 to 3 mm.	No reference value.
	Palpation	Absence of suppuration.	
	Radiographic examination	There may be bone loss. Clinical health in the intact or reduced periodontium.	Bone loss might be present. If present, ≤ 2 mm during or after the first year in function, relative to bone level on the date of prosthesis installation. Or < 3 mm, in the absence of a previous radiograph, from the date of the installation of the prosthesis.

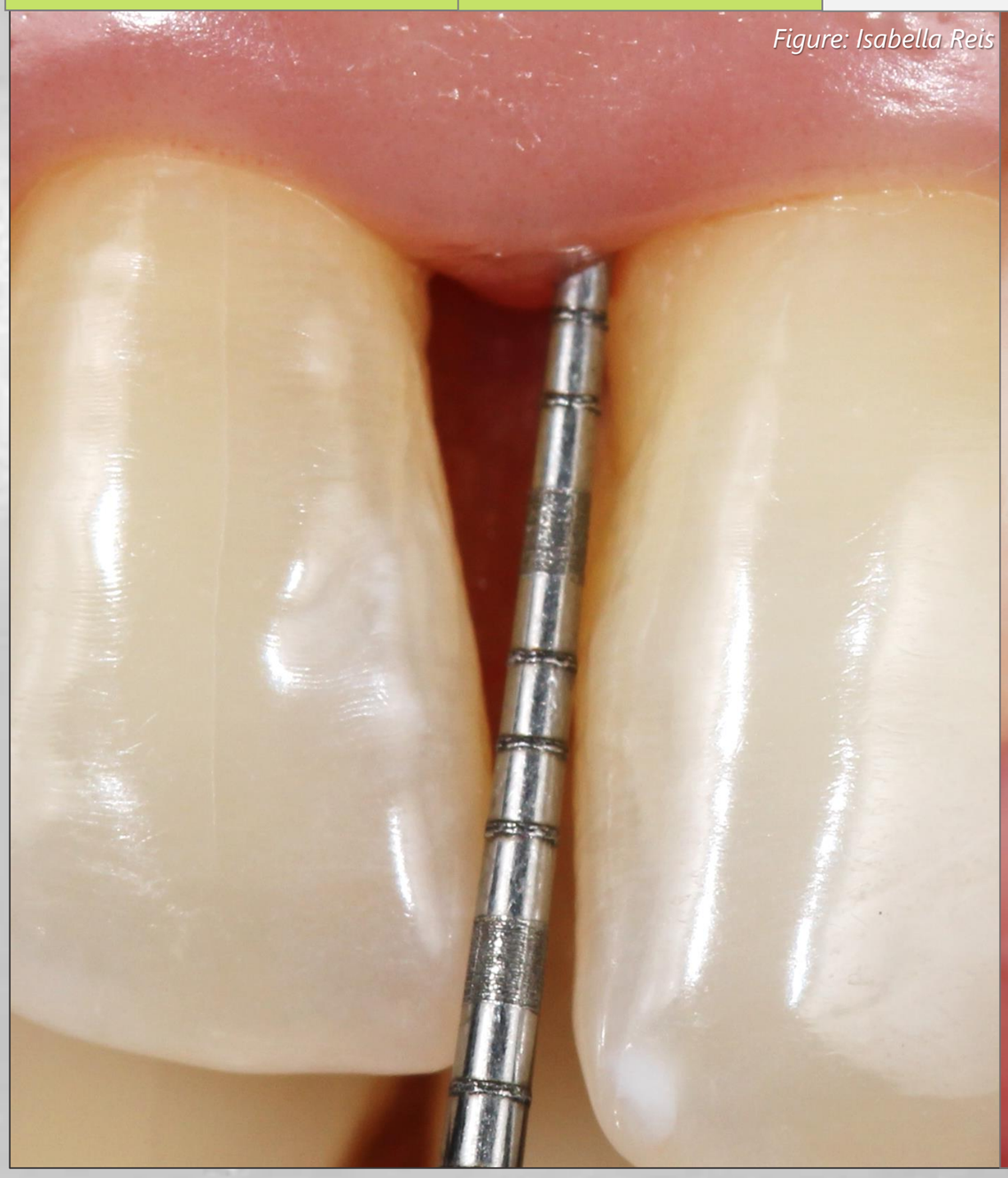

Figure: Isabella Reis

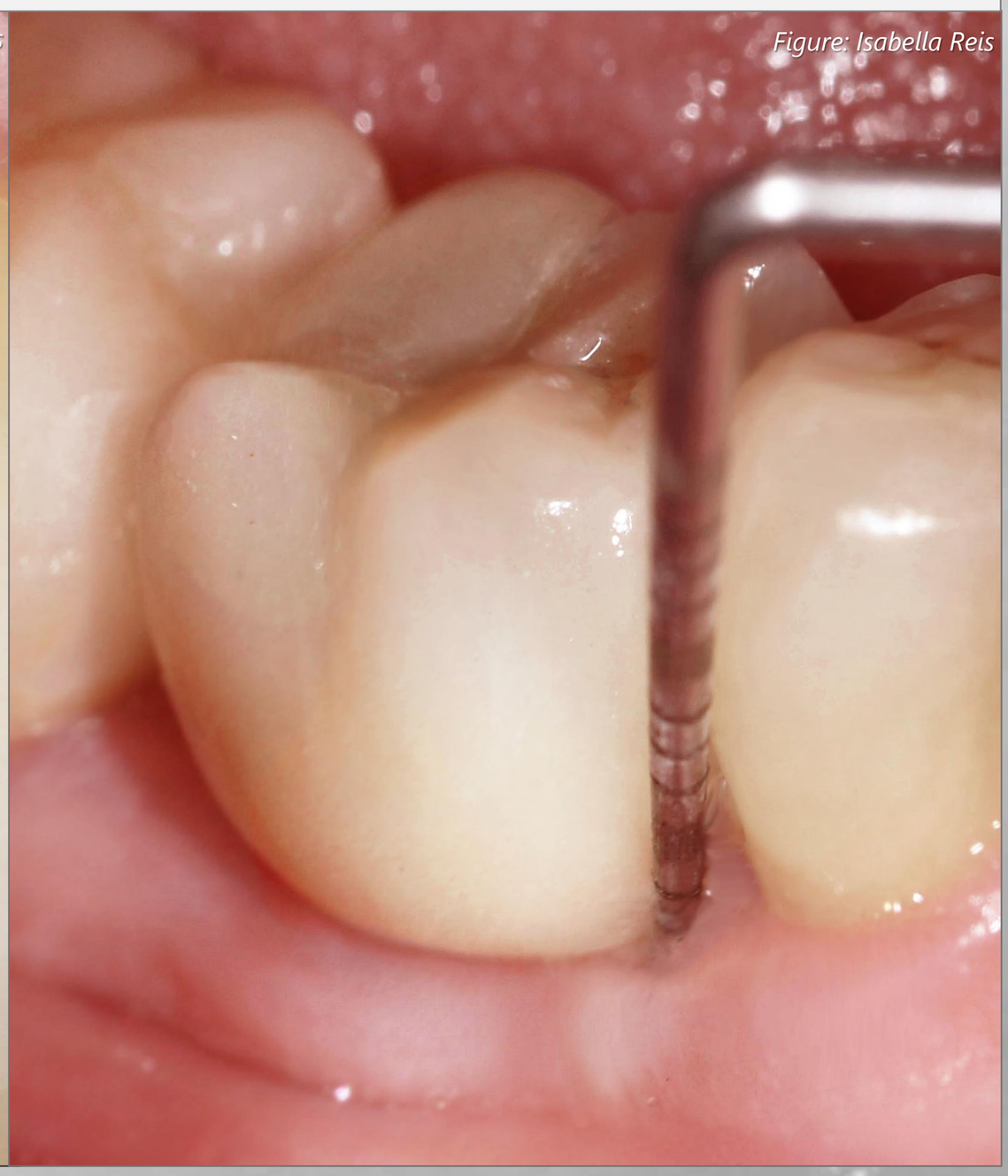

Figure: Isabella Reis

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CHAPTER 06

Peri-implant mucositis

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NOELE NASCIMENTO UTRERA

Figure: Isabella Reis

Peri-implant mucositis

1. What is the peri-implant mucositis?	Peri-implant mucositis is **an inflammatory disease of the mucosa surrounding an osseointegrated implant without progressive loss of bone support**. Peri-implant mucositis is the precursor of peri-implantitis. Its diagnosis and treatment are fundamental to avoid its evolution and consequent peri-implant bone loss.
2. What are the clinical and radiographic parameters of peri-implant mucositis?	**1. VISUAL INSPECTION: Clinical signs of inflammation of the peri-implant mucosa (redness and swelling)** **2. PROBING OF THE PERI-IMPLANT TISSUES:** • Bleeding on probing and/or suppuration. • There may be an increase in PD compared to that verified on the day of installation of the prosthesis. • In the absence of previous PD data: There is an association between PD ≤ 5.0 mm and peri-implant health. However, this parameter should not be considered in isolation. The clinical signs of inflammation and bleeding/perforation on probing are more important and decisive in the diagnostic process. • **NOTE:** Peri-implant mucositis is always accompanied by clinical signs of inflammation and bleeding on probing. • Probing should be performed using light forces to avoid inducing bleeding from tissue injury. **3. DIGITAL PALPATION:** Suppuration may be present. **4. RADIOGRAPHIC EVALUATION:** Bone loss ≤ 2 mm at any time during or after the first year of denture installation (first year in function). Or, in the absence of the periapical radiograph from the date of denture installation, radiographic evidence of bone loss < 3 mm.

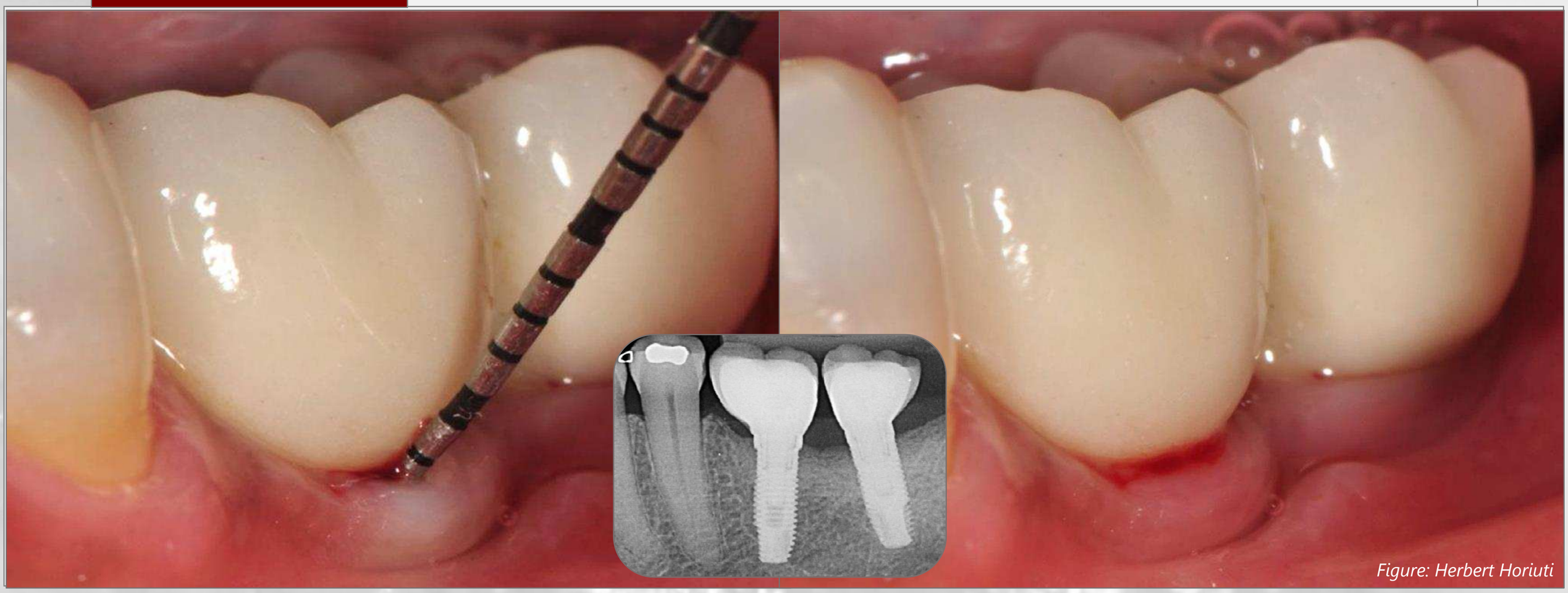

Figure: Herbert Horiuti

Peri-implant mucositis

3. What are the differences between gingivitis and peri-implant mucositis?	Clinical and radiographic examination	GINGIVITIS	PERI-IMPLANT MUCOSITIS
	Visual inspection	Presence of redness and swelling.	
	Probing	Bleeding and/or suppuration on probing.	
		PD from 1 to 3 mm	No reference value. Increase in PD concerning that verified on the day of the prosthesis installation.
	Palpation	Suppuration may be present (acute cases).	Suppuration may be present.
	Radiographic examination	Bone loss might be present (reduced periodontal gingivitis) or not (intact periodontal gingivitis).	Bone loss might be present. If present, ≤ 2 mm during or after the first year in function, concerning the bone level on the date of the prosthesis installation. Or < 3 mm in the absence of a previous radiograph from the date of prosthesis installation.

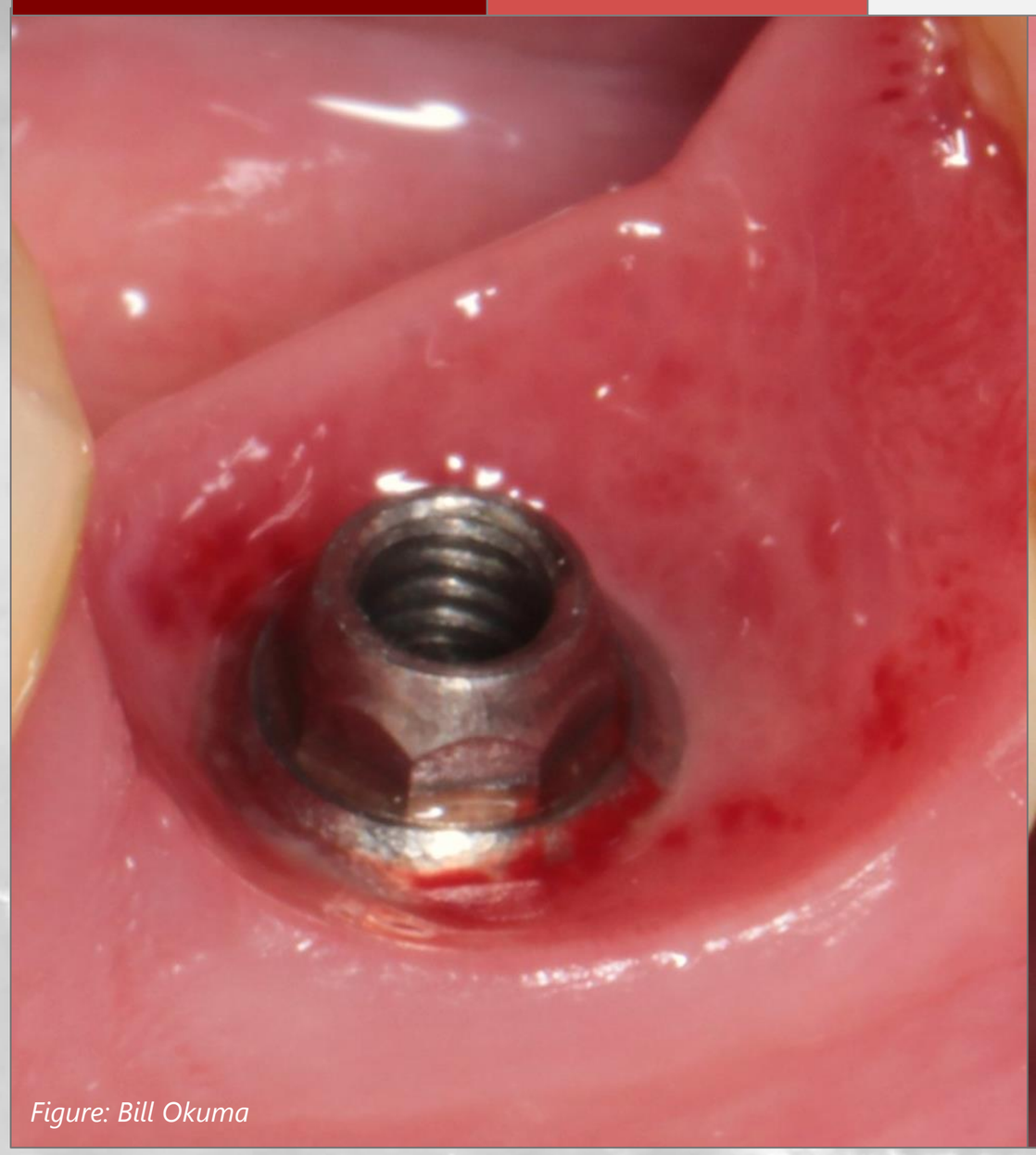

Figure: Bill Okuma

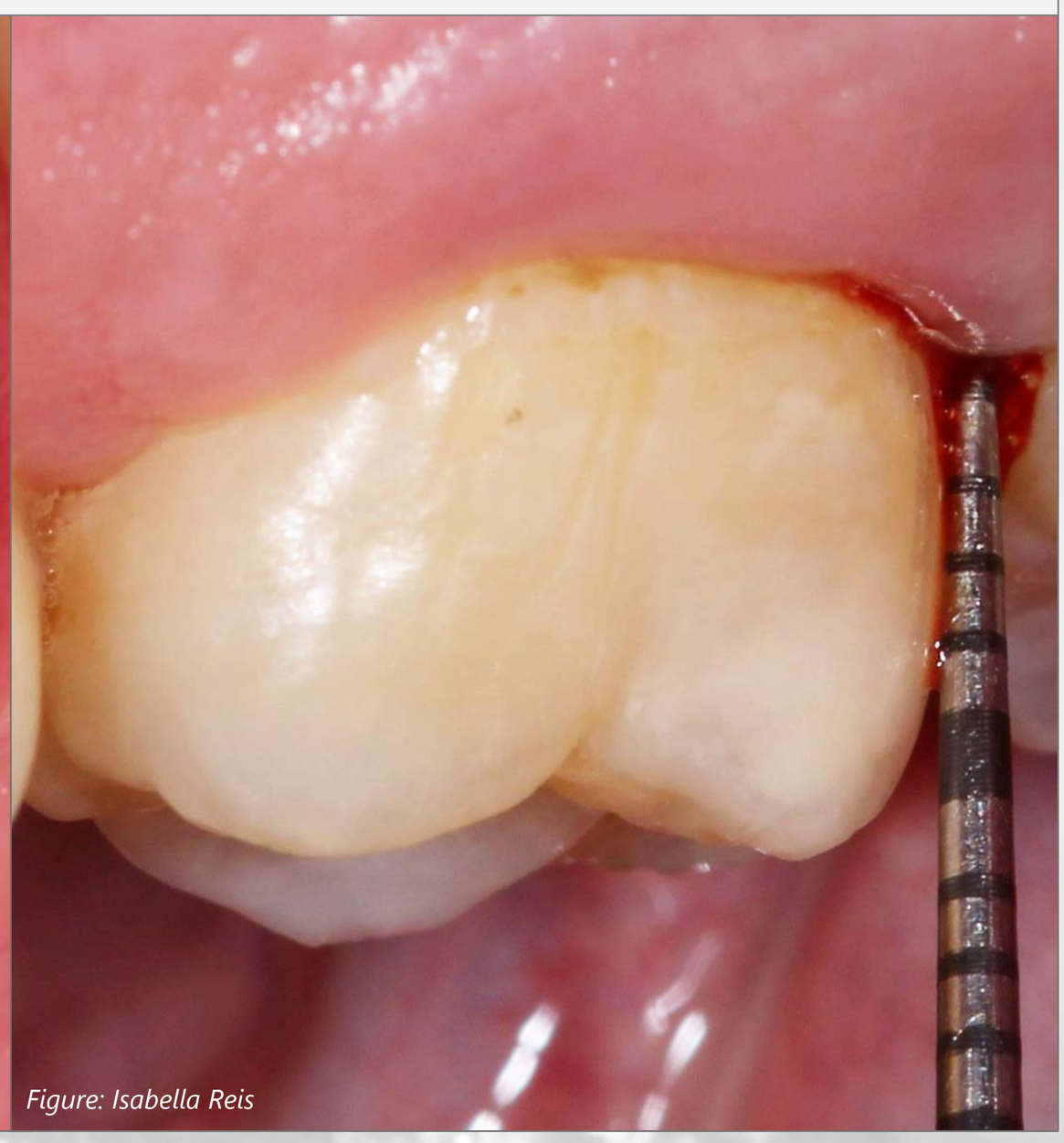

Figure: Isabella Reis

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CHAPTER 07

Peri-implantitis

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JOÃO BATISTA CÉSAR NETO
NAYARA TOLEDO DE LUCENA

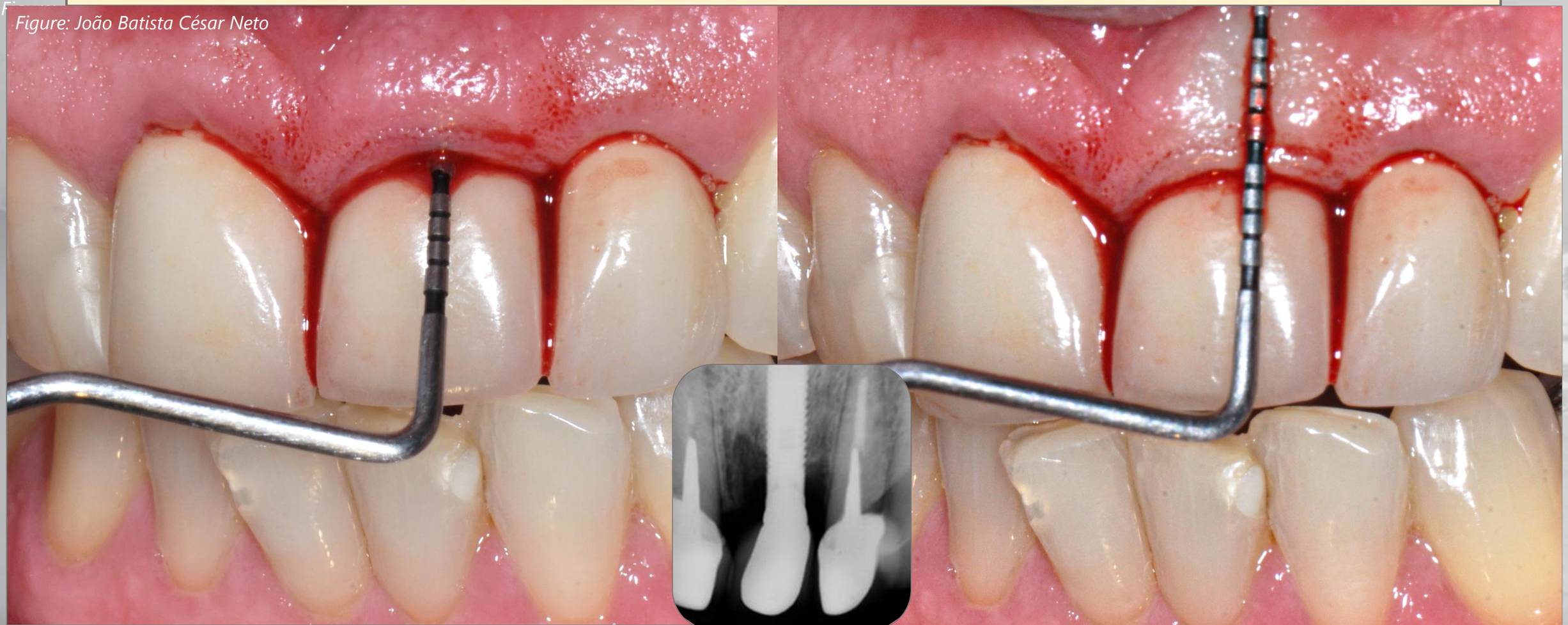
Figure: Isabella Reis

Peri-implantitis

1. What is peri-implantitis?	Peri-implantitis is an inflammatory disease that affects the peri-implant tissues. It is characterized by **inflammation of the peri-implant soft tissues and progressive loss of the supporting bone**. Peri-implantitis is defined by the same clinical inflammatory signs that define peri-implant mucositis, with the addition of **radiographic bone loss**.
2. What are the clinical and radiographic parameters of peri-implantitis?	**1. VISUAL INSPECTION:** Clinical signs of inflammation of the peri-implant mucosa (redness and swelling) **2. PROBING OF THE PERI-IMPLANT TISSUES:** • Bleeding on probing and/or suppuration. • Increased PD compared to that verified on the day of prosthesis installation or recession of the peri-implant mucosa margin. • In the absence of clinical probing depth data from the denture installation date, PD ≥ 6 mm associated with bleeding on probing represents peri-implantitis. **3. DIGITAL PALPATION:** Suppuration may be present. **4. RADIOGRAPHIC EVALUATION:** Evidence of progressive bone loss. Bone loss > 2 mm during or after the first year of denture installation (first year in function) relative to the bone level verified on the day of denture installation, or, in the absence of the periapical radiograph of the date of prosthesis installation, bone loss ≥ 3 mm, associated with bleeding on probing. *Concept of progressive bone loss: see Chapter 3.

NOTE: Despite the inherent difficulties in the treatment of peri-implantitis, it can be successfully treated in some cases. In instances where peri-implantitis has been treated and attachment and bone loss arrested, the clinical parameters will be compatible with health despite the existing bone loss due to the previous peri-implantitis. For example, peri-implant radiographic bone loss without clinical signs of inflammation, bleeding on probing, and/or suppuration.

Figure: João Batista César Neto



Peri-implantitis

3. What are the differences between periodontitis and peri-implantitis?	**Clinical and radiographic examination**	**PERIODONTITIS**	**PERI-IMPLANTITIS**
	Inspeção visual	Presence of redness and swelling.	
	Probing	Bleeding and/or suppuration on probing.	
		PD > 3 mm	PD ≥ 6.0 mm associated with bleeding on probing.
	Palpation	Suppuration may be present.	
	Radiographic examination	There is bone loss. Although there is no reference value for the diagnosis.	Bone loss > 2 mm in relation to the bone level on the day of the prosthesis installation or ≥ 3 mm, in the absence of a previous radiograph from the date of prosthesis installation, associated with bleeding on probing.

Figure: Isabella Reis

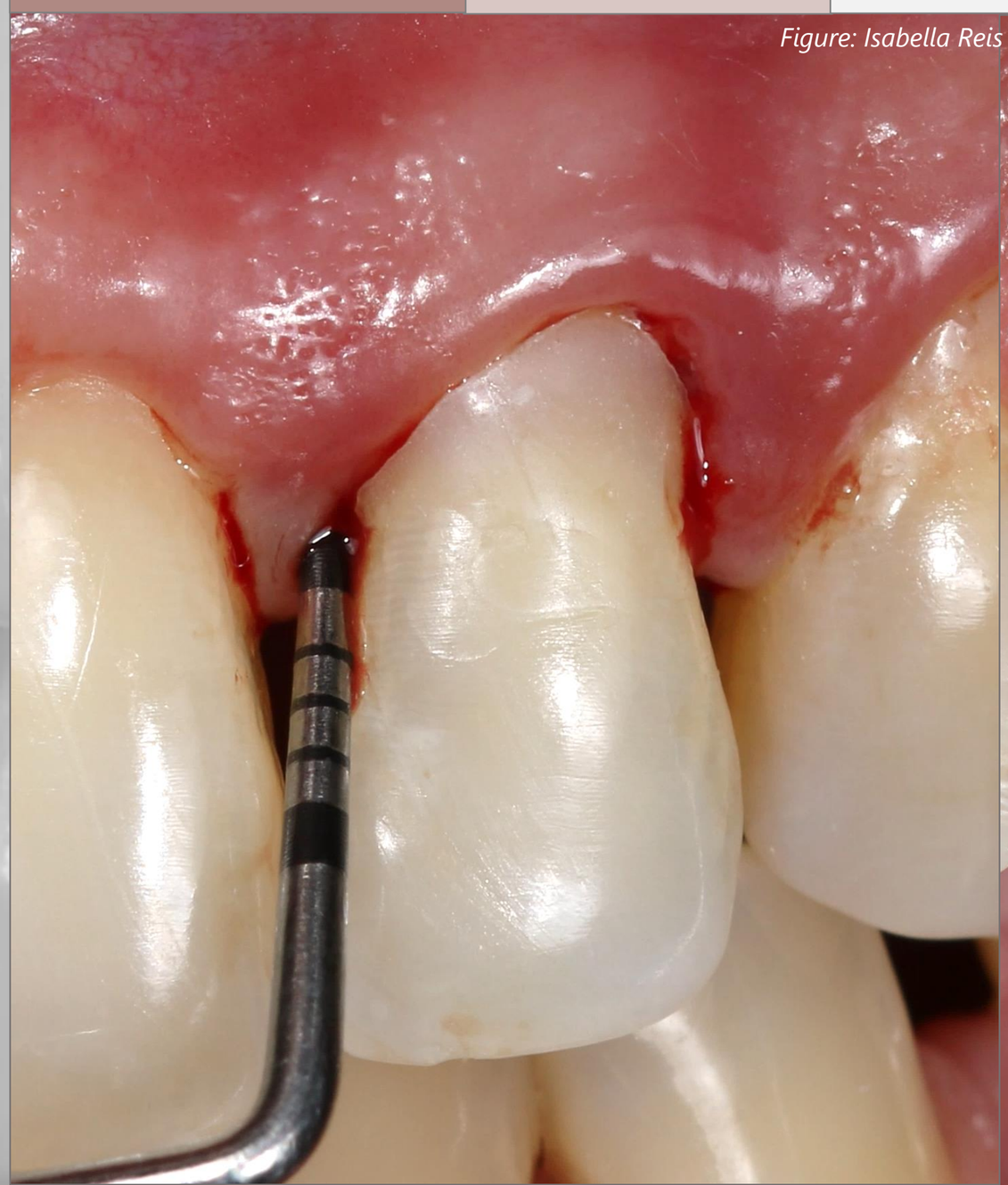
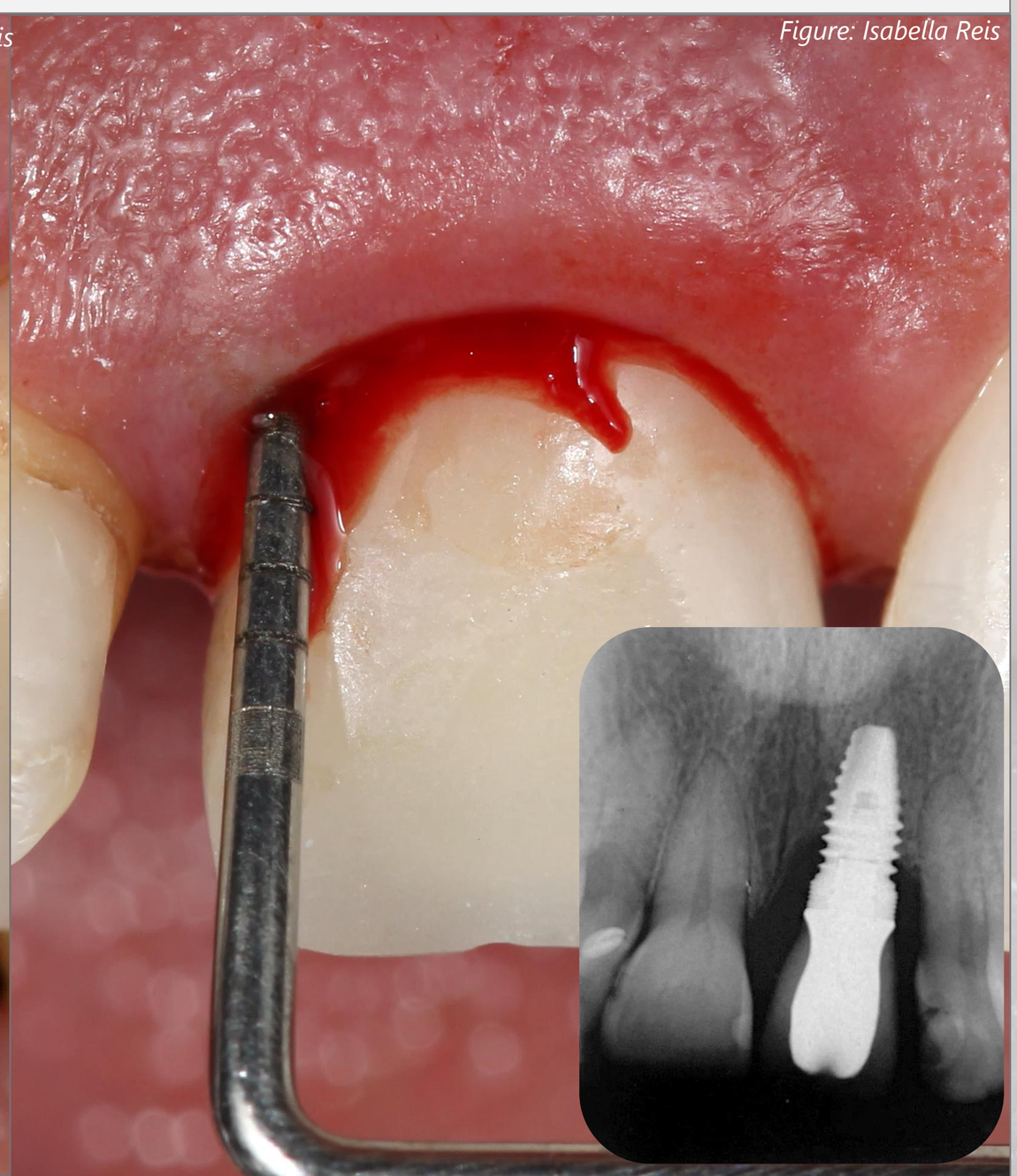


Figure: Isabella Reis



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CHAPTER 08

Review of peri-implant diseases: Flowchart and mental map

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Review: Flowchart for diagnosis

Visual inspection, digital palpation and probing

Presence of:
- **Bleeding and/or suppuration on probing.**
- **Redness and swelling.**
- **PD increase in relation to the PD of the previous exam.**

Absence of:
- **Bleeding and/or suppuration on probing.**
- **Redness and swelling.**
- **PD increase in relation to the PD of the previous exam.**

Bleeding on probing is the most important criterion in distinguishing between peri-implant health and disease.

Peri-implant health

Radiograph (periapical radiography)

Radiographic bone loss is the most important criterion in distinguishing between peri-implant mucositis and peri-implantitis.

Patient with previous radiograph

Bone loss* ≤ 2 mm in relation to the bone level on the date the prosthesis installation, at any time during or after the 1st year of function. → Peri-implant mucositis

Bone loss* > 2 mm from the previous bone level, at any time during or after the 1st year of function. → Peri-implantitis

Patient without previous radiograph

Bone loss* < 3 mm → Peri-implant mucositis

Bone loss* ≥ 3 mm → Peri-implantitis

***Bone loss** measured from the most coronal portion of the intraosseous part of the implant to the bone level.

Is there a **probing depth reference value** for distinguishing between health and disease?

No, clinical signs of inflammation and bleeding on probing are more important.
In the absence of **probing depth data** from the day of implant placement,
PD ≥ 6 mm associated with bleeding on probing represents peri-implantitis.

Review: Mental map

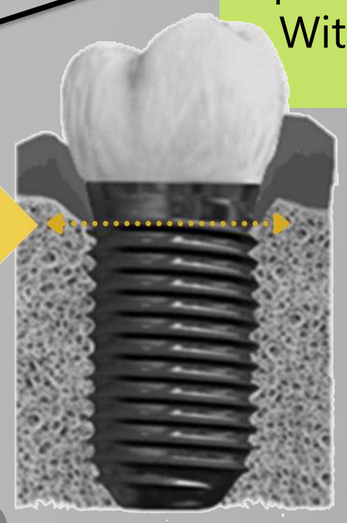
Absence of bleeding and/or suppuration on probing or digital palpation.

PD compatible with health: There is no parameter defined - clinical signs + important.

No redness and swelling.

Absence of progressive bone loss. With radiograph of the date of prosthesis installation: ≤ 2mm. Without radiography: < 3 mm

PERI-IMPLANT HEALTH

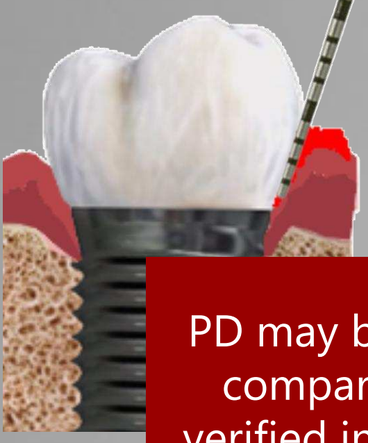


Redness and swelling.

CLASSIFICATION OF PERI-IMPLANT DISEASES AND CONDITIONS

Redness and swelling.

Presence of bleeding and/or suppuration on probing or digital palpation.



PERI-IMPLANT MUCOSITIS

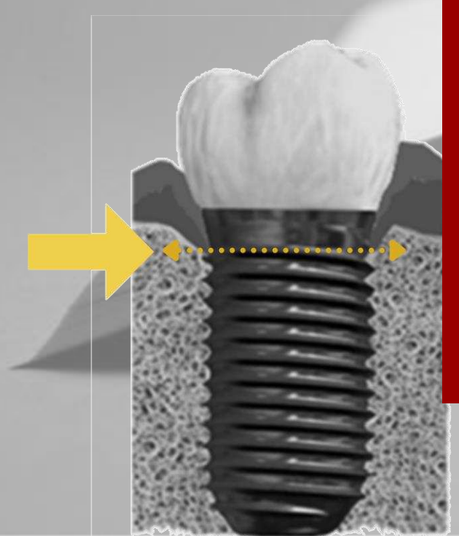
PERI-IMPLANTITIS

Presence of bleeding and/or suppuration on probing or digital palpation.

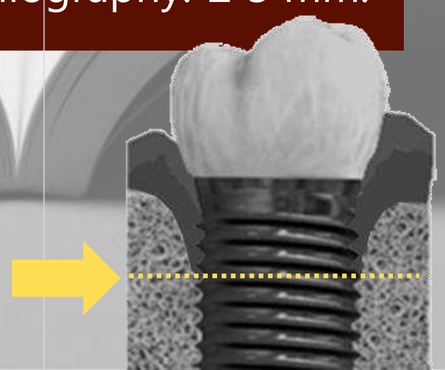
PD may be increased compared to that verified in the date of prosthesis installation.

Presence of progressive bone loss. With the radiography of the date of prosthesis installation: > 2mm. Without the radiography: ≥ 3 mm.

PD may be increased compared to that verified in the date of prosthesis installation or PD 6 mm associated with bleeding on probing.



Absence of progressive bone loss. With the radiography of the date of prosthesis installation: > 2mm. Without the radiography: ≥ 3 mm.



Peri-implant recession should also be analysed.

CHAPTER 09

Peri-implant hard- and soft-tissues deficiencies

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LUCIANA SARAIVA
MARINELLA HOLZHAUSEN

Figure: Isabella Reis

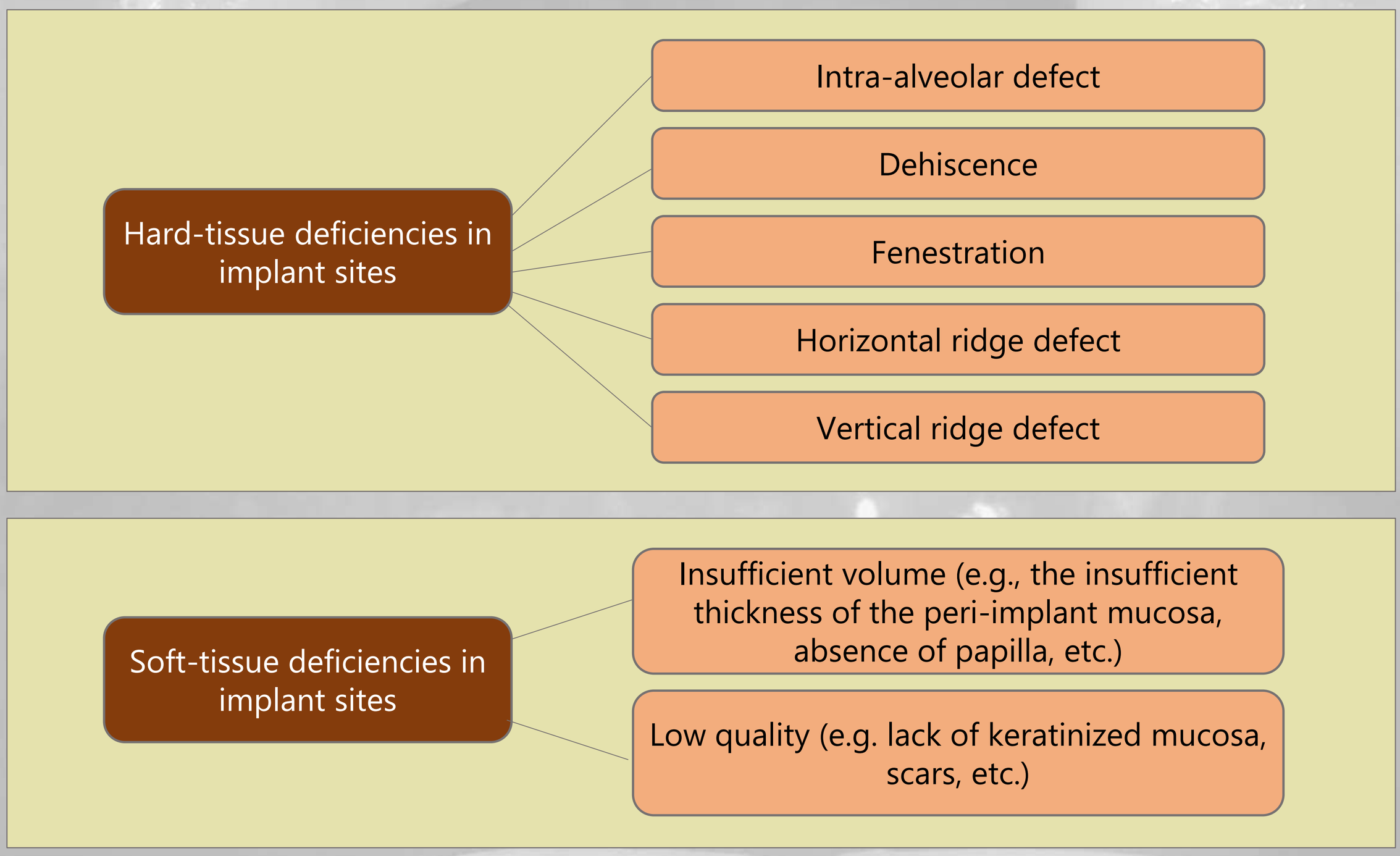
Peri-implant hard- and soft-tissues deficiencies

Tissue deficiencies in implant regions are common clinical findings. Their presence can increase marginal bone loss, soft tissue inflammation, and soft tissue recession. These complications are challenging to treat and can threaten implant survival.

This chapter, which is based on the article by Hammerle and colleagues (2017), aims to describe the factors associated with and/or to cause peri-implant tissue deficiencies.

Hard and soft-tissue deficiencies at implant sites may result from various factors. However, **varying levels of scientific evidence** are available to support an association or causal relationship for these factors concerning hard and soft tissue deficiencies; there is a good level of evidence for some, while for others, there is little or no scientific evidence. Further research is needed to better identify the factors leading to hard and soft-tissue deficiencies and their clinical impact on implant treatment.

Nevertheless, all the factors considered possible causes of these deficiencies are presented below:



Peri-implant hard- and soft-tissues deficiencies

<u>Hard-tissue</u> deficiencies in implant sites

1. Prior to implant placement

2. After implant placement

<u>Factors associated with or causing disabilities</u>

Tooth loss

Trauma from tooth extraction

Systemic diseases

Bone height in the posterior maxilla (area of the sinus floor)

1. Hard-tissue deficiencies **prior** to implant placement

Periodontitis

General trauma

Longitudinal root fractures

Endodontic infections

Defects in the health situations
(e.g. fenestrations, dehiscence, etc.)

Systemic diseases

Malpositioning of implants

2. Hard-tissue deficiencies **after** implant placement

Soft-tissue thickness

Peri-implantitis

Mechanical overload

Peri-implant hard- and soft-tissues deficiencies

<u>Soft-tissue</u> deficiencies in implant sites

1. Prior to implant placement

2. After implant placement

<u>Factors associated with or causing disabilities</u>

Tooth loss

Systemic diseases

1. Soft-tissue deficiencies **prior** to implant placement

Periodontal disease

Lack of buccal bone

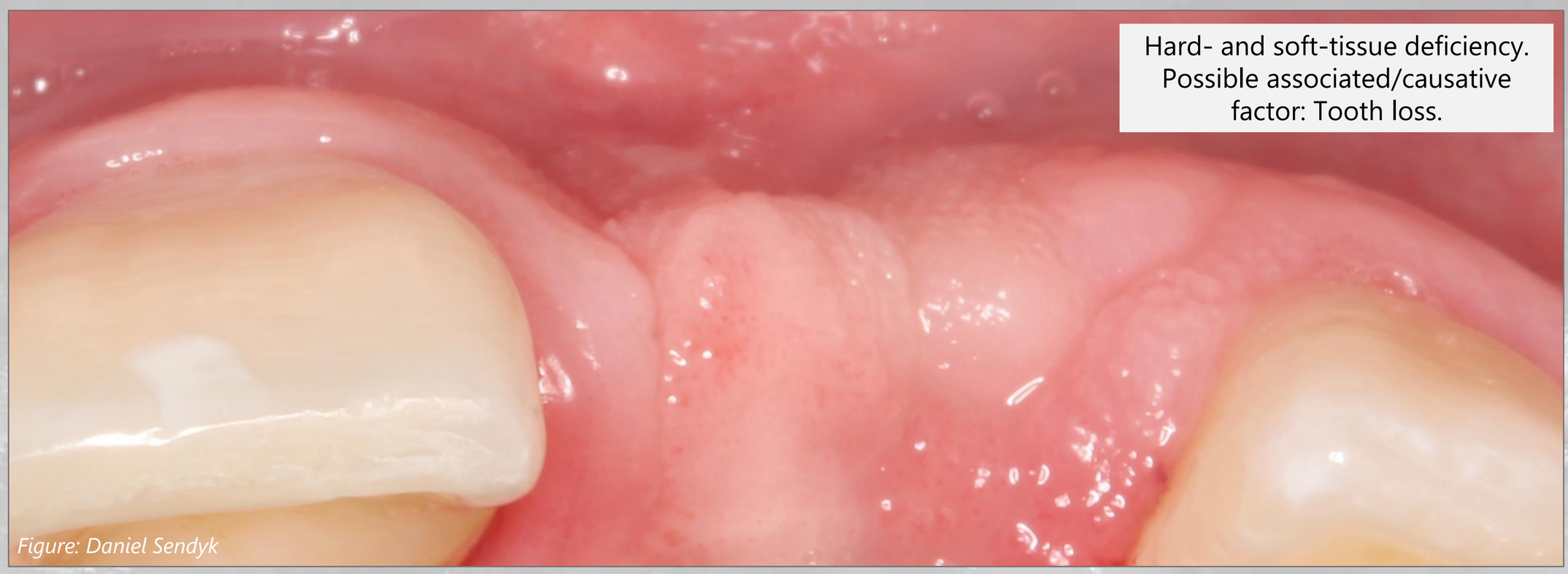
Migration of teeth and life-long skeletal changes

2. Soft-tissue deficiencies **after** implant placement

Papilla height

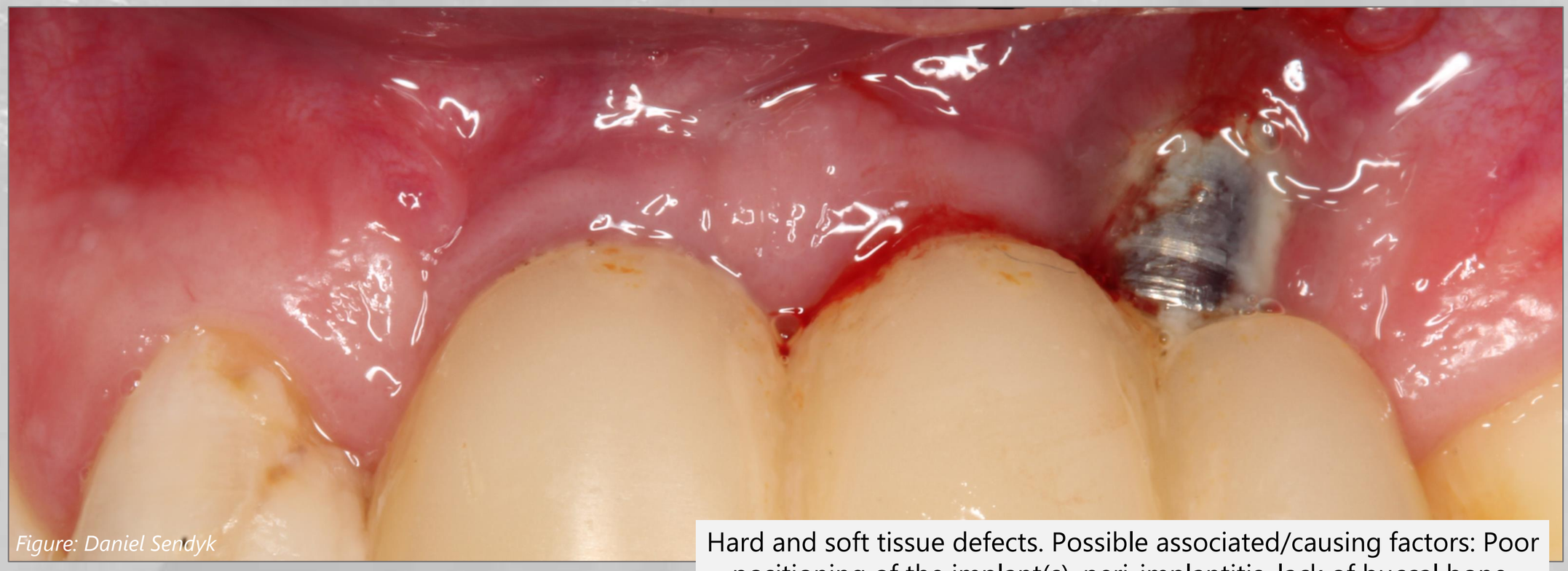
Keratinized tissue

Peri-implant hard and soft tissues deficiencies



Hard- and soft-tissue deficiency. Possible associated/causative factor: Tooth loss.

Figure: Daniel Sendyk



Hard and soft tissue defects. Possible associated/causing factors: Poor positioning of the implant(s), peri-implantitis, lack of buccal bone, lack of keratinized mucosa, insufficient soft tissue thickness.

Figure: Daniel Sendyk

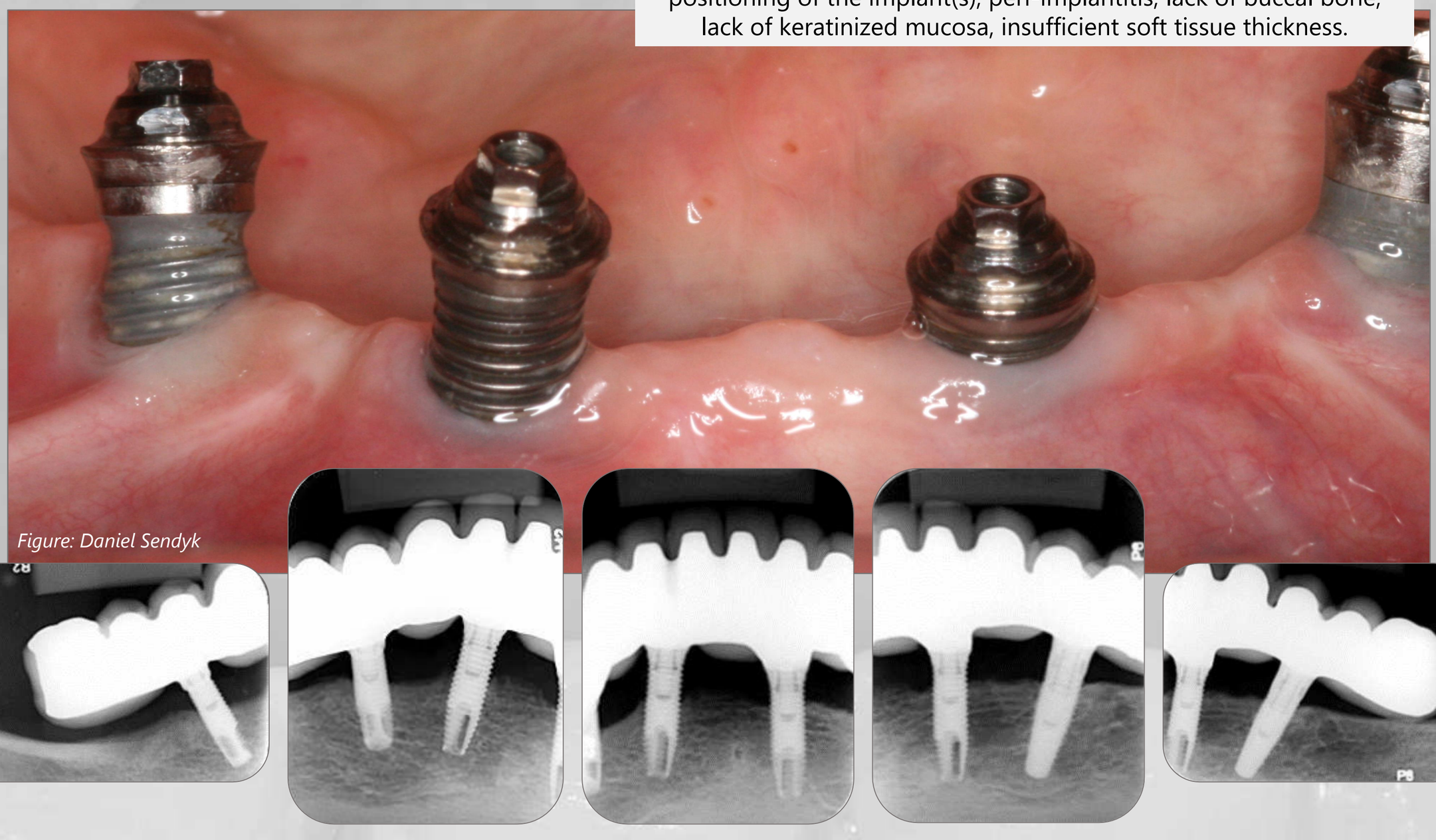
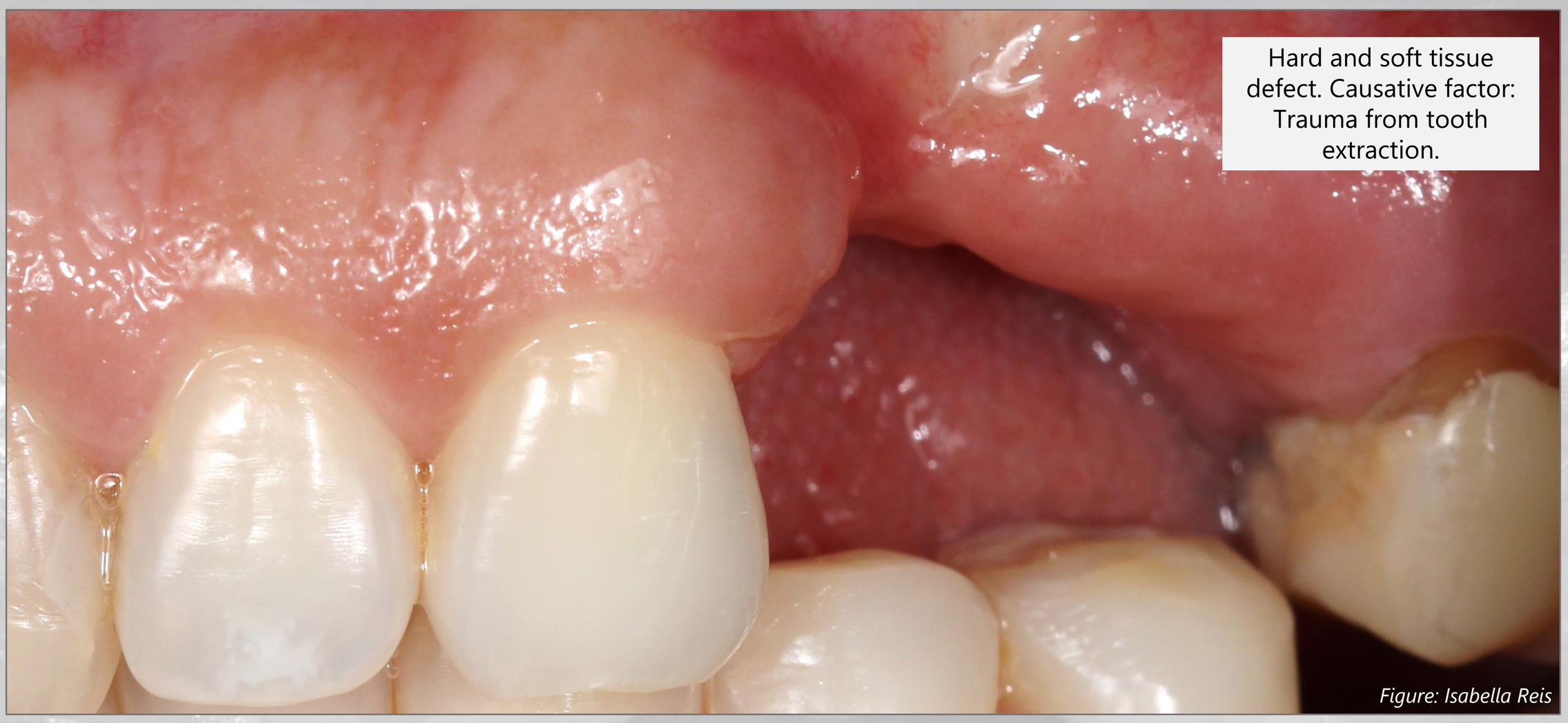


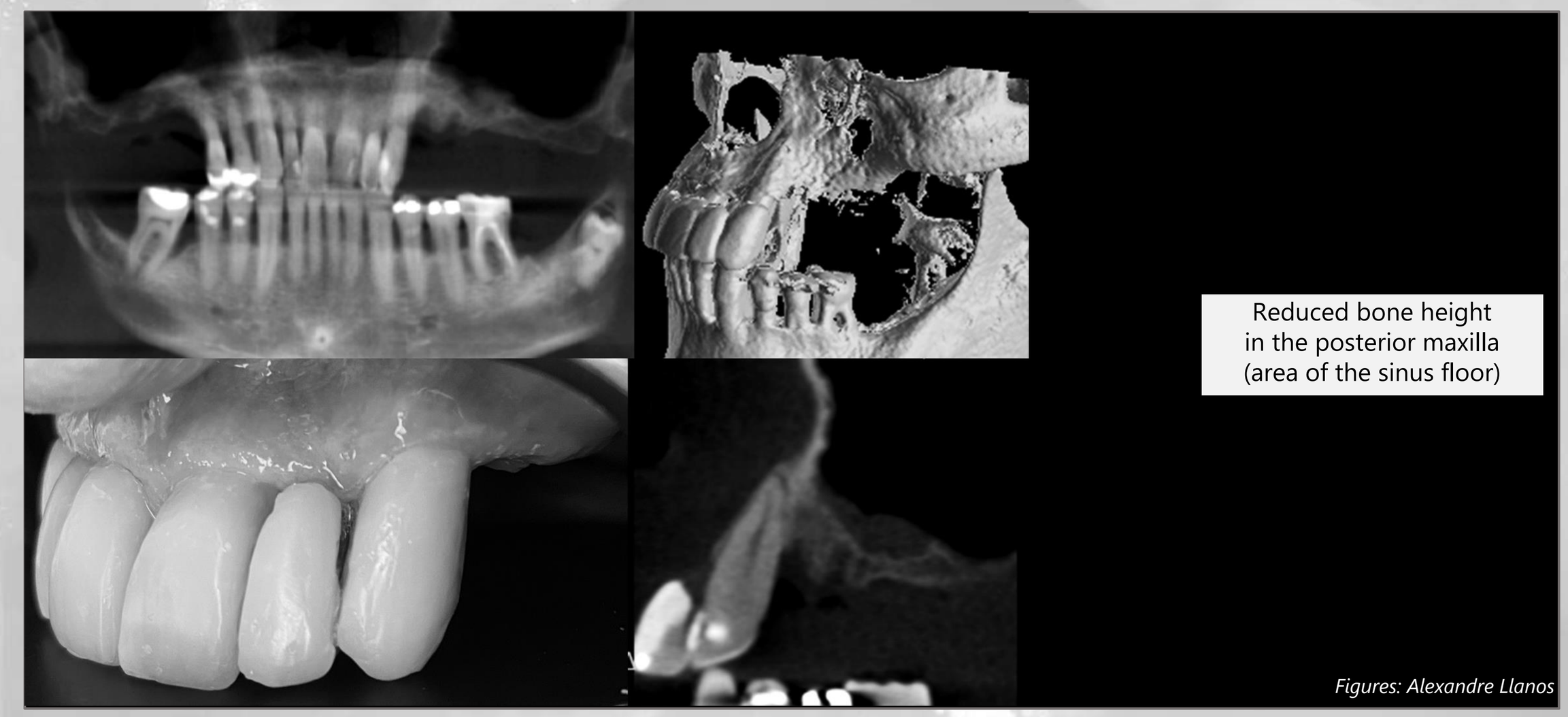
Figure: Daniel Sendyk

Peri-implant hard and soft tissues deficiencies



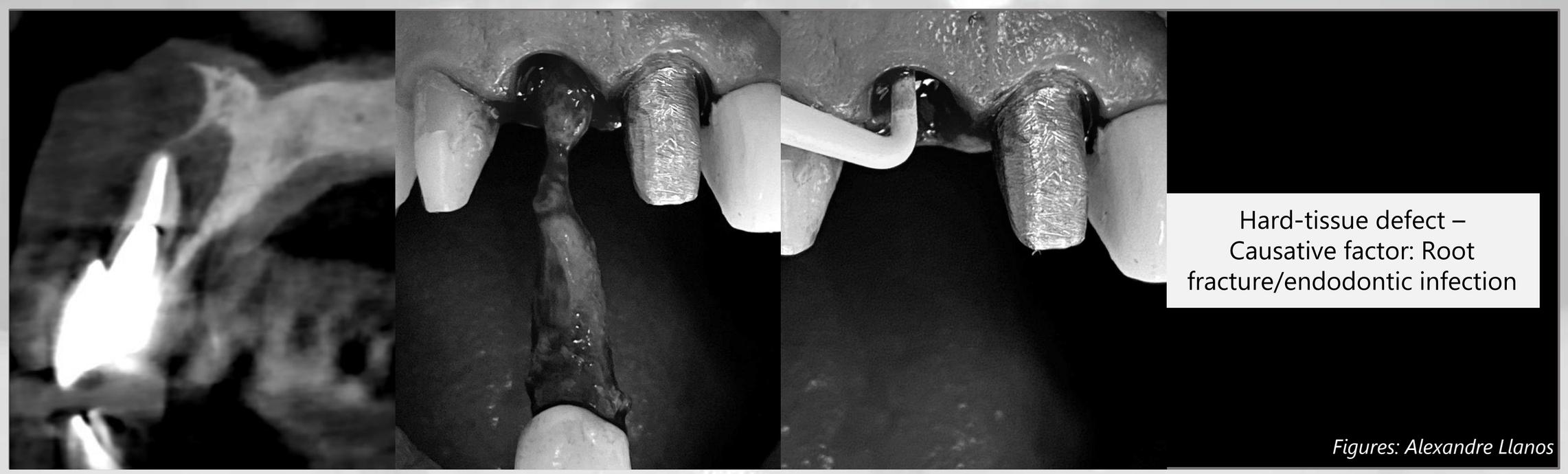
Hard and soft tissue defect. Causative factor: Trauma from tooth extraction.

Figure: Isabella Reis



Reduced bone height in the posterior maxilla (area of the sinus floor)

Figures: Alexandre Llanos



Hard-tissue defect – Causative factor: Root fracture/endodontic infection

Figures: Alexandre Llanos

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CHAPTER 10

Figure: Isabella Reis

Implant success, survival and failure

Figure: Bill Okuma

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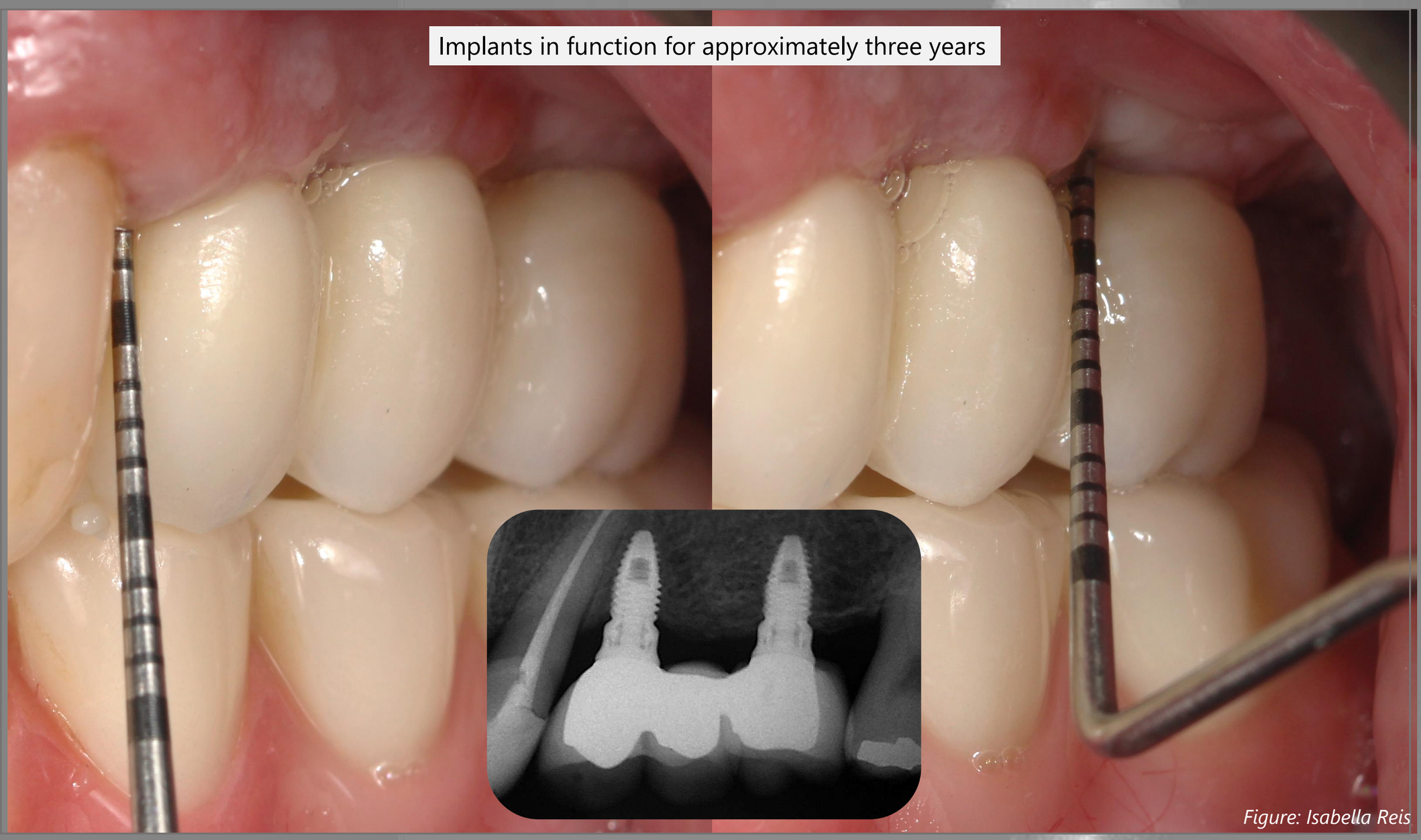
Implant success, survival and failure

1. Implant success

The term ‘success’ is used to describe implants in an ideal clinical condition. Although there is no consensus and several criteria have been proposed over the years, the success criteria proposed by Albrektson and colleagues (1986) remain the most widely used (Moraschini et al., 2015). They are:

1. Success criteria of Albrektson and collaborators (1986):	1. The implant (unitary) **does not show mobility** when clinically tested. 2. There is **no evidence of radiolucency around the implant** on radiography. 3. Radiographic bone loss should be **no more than 1.5mm in the first year** and **less than 0.2 mm annually** after the first year in function. 4. Absence of signs and symptoms such as **pain, infection, neuropathies, paresthesias, or violation of the mandibular canal.** 5. Considering the criteria mentioned above, the success rates are 85% and 80% at the end of the 5- and 10-year follow-up periods, respectively.



Implants in function for approximately three years

Figure: Isabella Reis

Implant success, survival and failure

Besides the functional aspects, achieving **successful aesthetic results** is also an important goal of implant dentistry, mainly when this treatment is performed in aesthetic areas. Thus, indexes such as the **Pink Esthetic Score (PES)** and **White Esthetic Score (WES)** have been proposed to evaluate the esthetic result of implant-supported rehabilitation.

Pink Esthetic Score (PES) by Furhauser and colleagues (2005):

2. What is the Pink Esthetic Score (PES)?	It is the index indicated for evaluating peri-implant pink esthetics, i.e., soft tissue esthetics of single implants placed in the anterior region compared to the homologous natural tooth.
3. How is the aesthetic assessment conducted using PES?	The analysis must be performed through a frontal digital photograph. The dental element and its counterpart are contemplated, which is performed with a lip retractor and black background. Points are assigned for different clinical parameters. The possible scores for each parameter **are 2, 1, or 0.** A score of 10 is attributed to an excellent result, while a score of 6 is attributed to a result at the limit for clinical acceptance of the treatment.

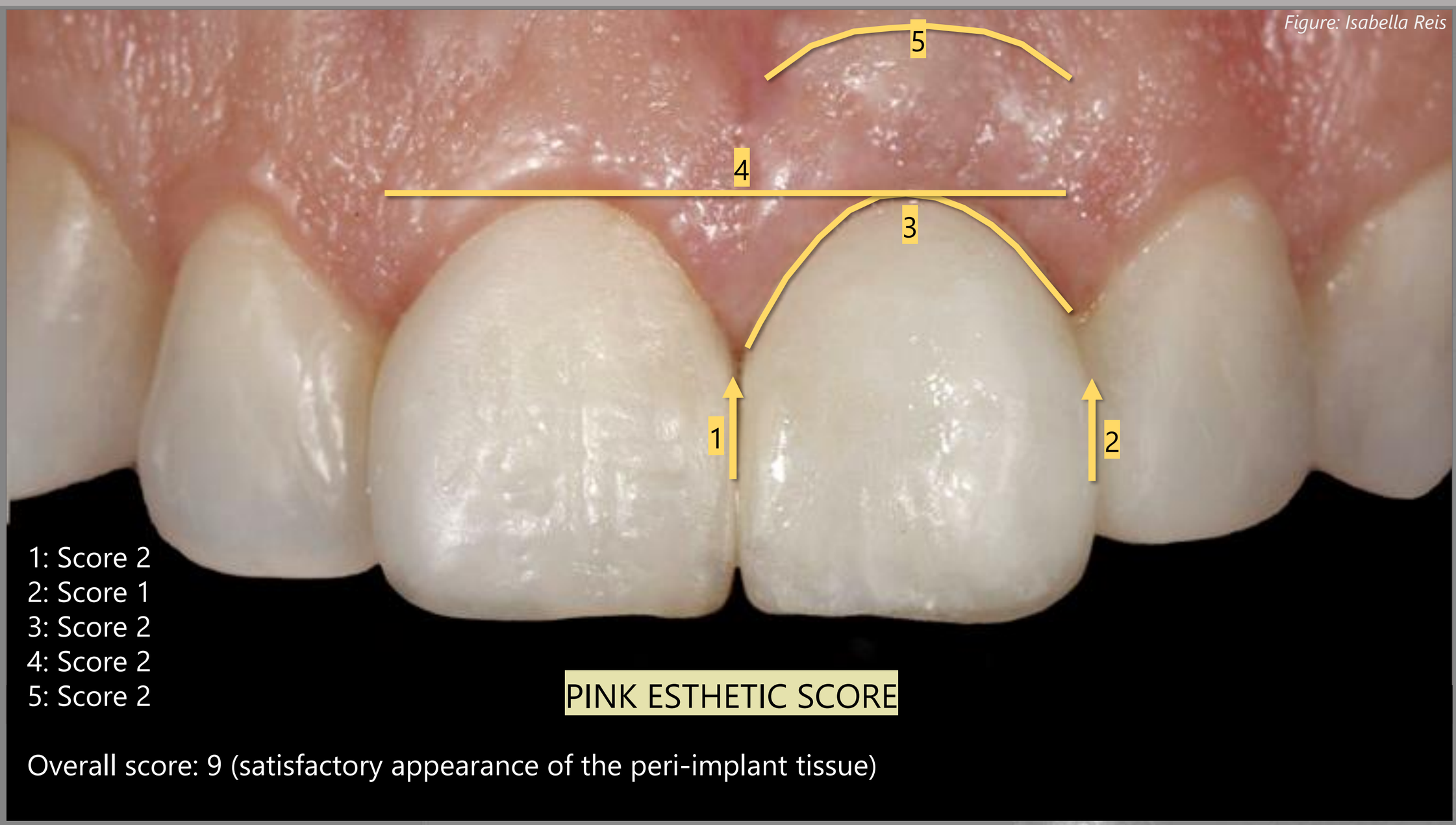
Figure: Isabella Reis

A CASE TO BE EVALUATED USING THE PES AND WES INDEXES

Implant success, survival and failure

4. What clinical parameters are evaluated with the PES, and how to score?

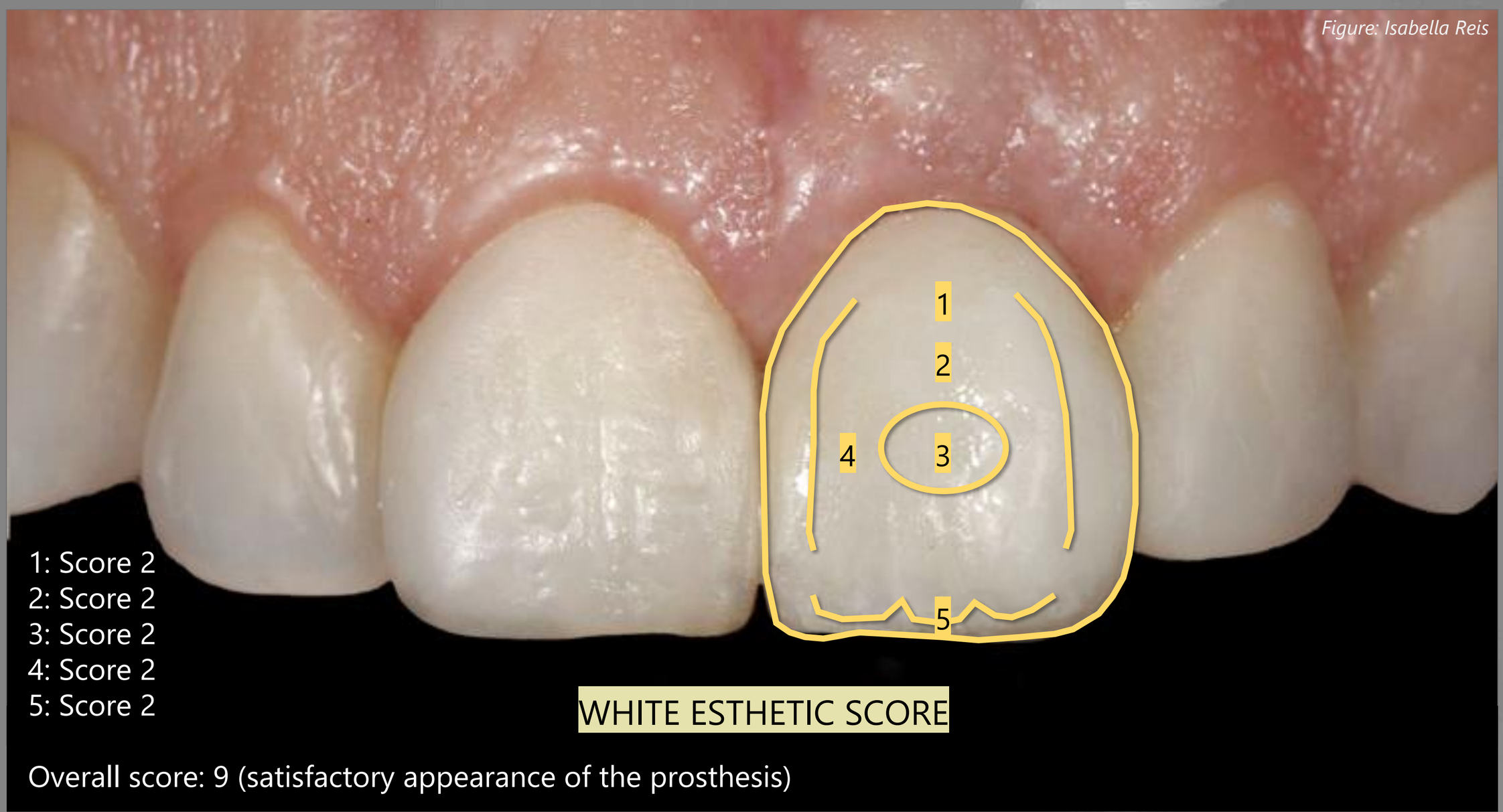
1. Mesial papilla and 2. Distal papilla:
2 – full presence.
1 – incomplete presence.
0 - absence.
3. Curvature of the vestibular mucosa:
2 - identical.
1 – slightly different.
0 – notably different.
4. Level of the vestibular mucosa:
2 – identical level.
1 – slightly discrepant (<1mm).
0 – discrepant (>1mm).
5. Root convexity, soft tissue color and texture on the buccal surface:
2 – if the three variables are similar to the control.
1 – if two criteria were similar to the control.
0 – if none or only one criterion is in agreement with the control.



Implant success, survival and failure

White esthetic score (WES) by Belser and colleagues (2009):

5. What is the White Esthetic Score (WES)?	The index indicated for evaluation of the white esthetics, i.e., the esthetics of the visible portion of the prosthetic crown, of single implants placed in the anterior region, compared to the homologous natural tooth.
6. How is the esthetic assessment performed using the WES?	The analysis must be performed through a frontal digital photograph. The dental element and its counterpart are contemplated, which is performed with a lip retractor and black background. Points are assigned for different clinical parameters. The possible scores for each parameter are **2, 1, or 0.** A score of 10 is attributed to an excellent result, while a score of 6 is attributed to a result at the limit for clinical acceptance of the treatment.
7. What clinical parameters are assessed using the WES, and how do they score?	**1. Crown shape** **2. Crown contour and volume** **3. Color** **4. Texture and surface** **5. Characterization and translucency**



Implant success, survival and failure

2. Implant survival

- Surviving implants are those that are **in less-than-ideal conditions**, which may or may not require clinical management, but fit **neither the success nor the failure criteria** (Esposito et al., 1988, Misch et al., 2008).
- These are stable implants that remain in function but demonstrate a **history of, or the potential for, clinical problems** (Baumer et al., 2020).
- Examples of **clinical problems** include loosening the fixation screw or prosthetic abutment, chipping of the veneering porcelain, fracture of the prosthetic crown, and fracture of the prosthetic abutment (Baumer et al., 2020).
- Implants affected by **biological complications** (treated or not) but that were solved, such as peri-implant mucositis or peri-implantitis, fistula, suppuration, and dehiscence (Baumer et al., 2020).

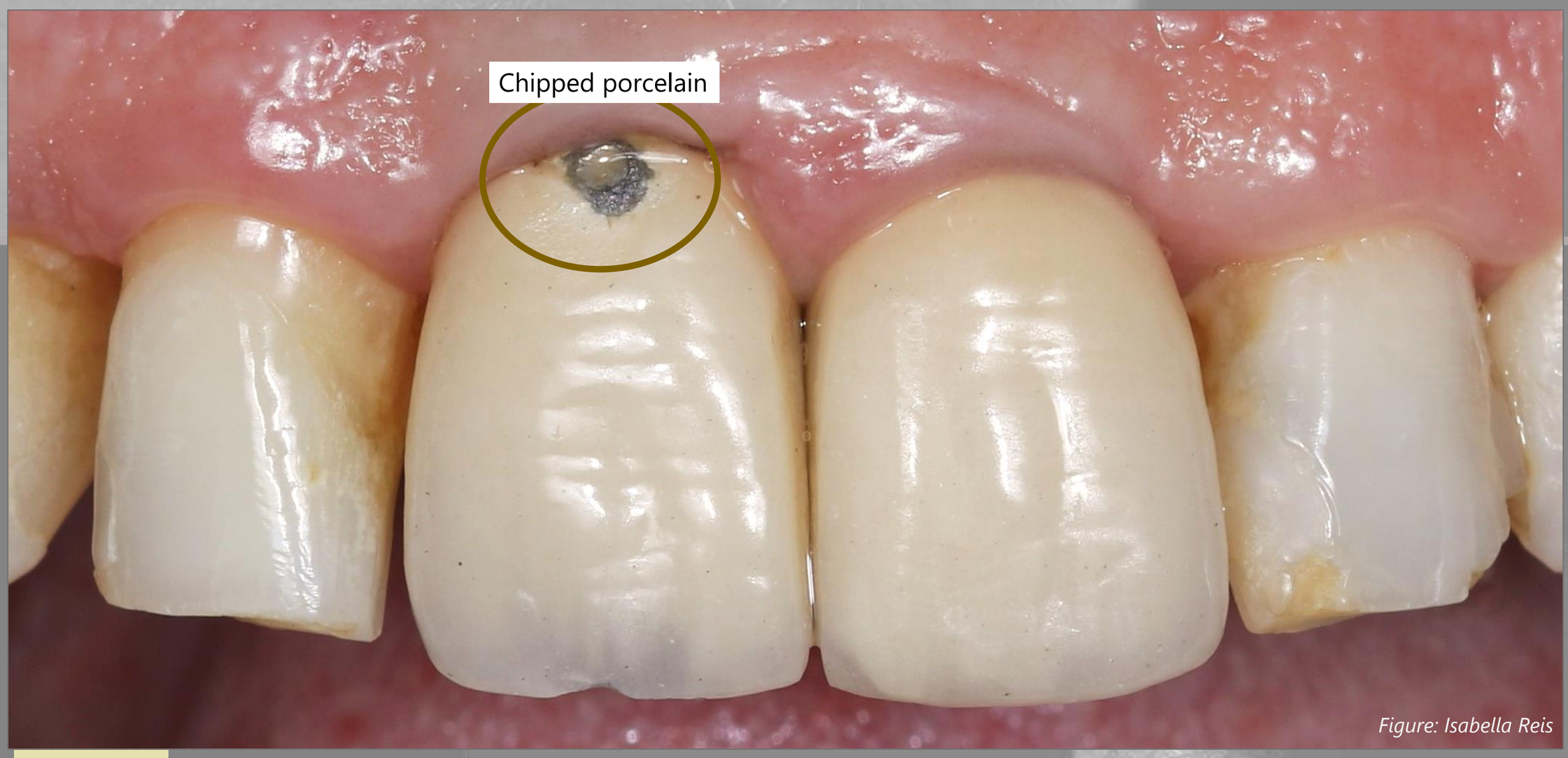


Figure: Isabella Reis

3. Failure

An implant is considered to have failed when **its removal is necessary** or when it **has already been removed.**

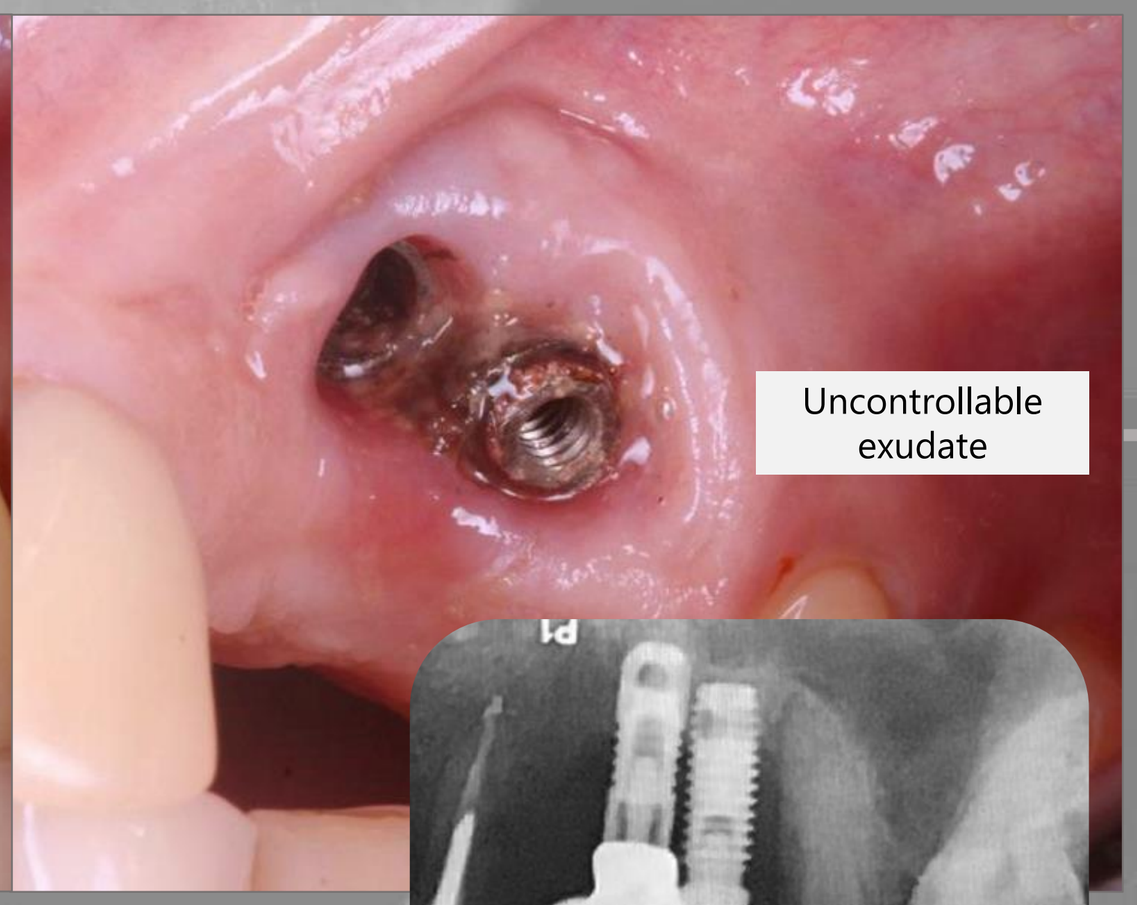
1. Criteria for implant failure were proposed by Misch and colleagues (2008):	1. Pain in function. 2. Mobility. 3. Radiographic bone loss is greater than half the implant length. 4. Uncontrollable exudate. 5. Implant is lost - no longer in the mouth.

Implant success, survival and failure

2. Classification of implant failure proposed by Esposito and colleagues (1988)

- **Biological**
  - Early (or primary) - before the implant is in function: Failure to establish osseointegration
  - Late (or secondary) - after the implant is in function: Failure to maintain osseointegration achieved
- **Mechanical:** Fracture of the implant, the fixation screw, or the structures of a fixed prosthesis
- **Iatrogenic:** Nerve damage, inadequate positioning, and others
- **Inadaptation by the patient:** Phonetic, aesthetic, psychological problems, and others

Figure: Isabella Reis



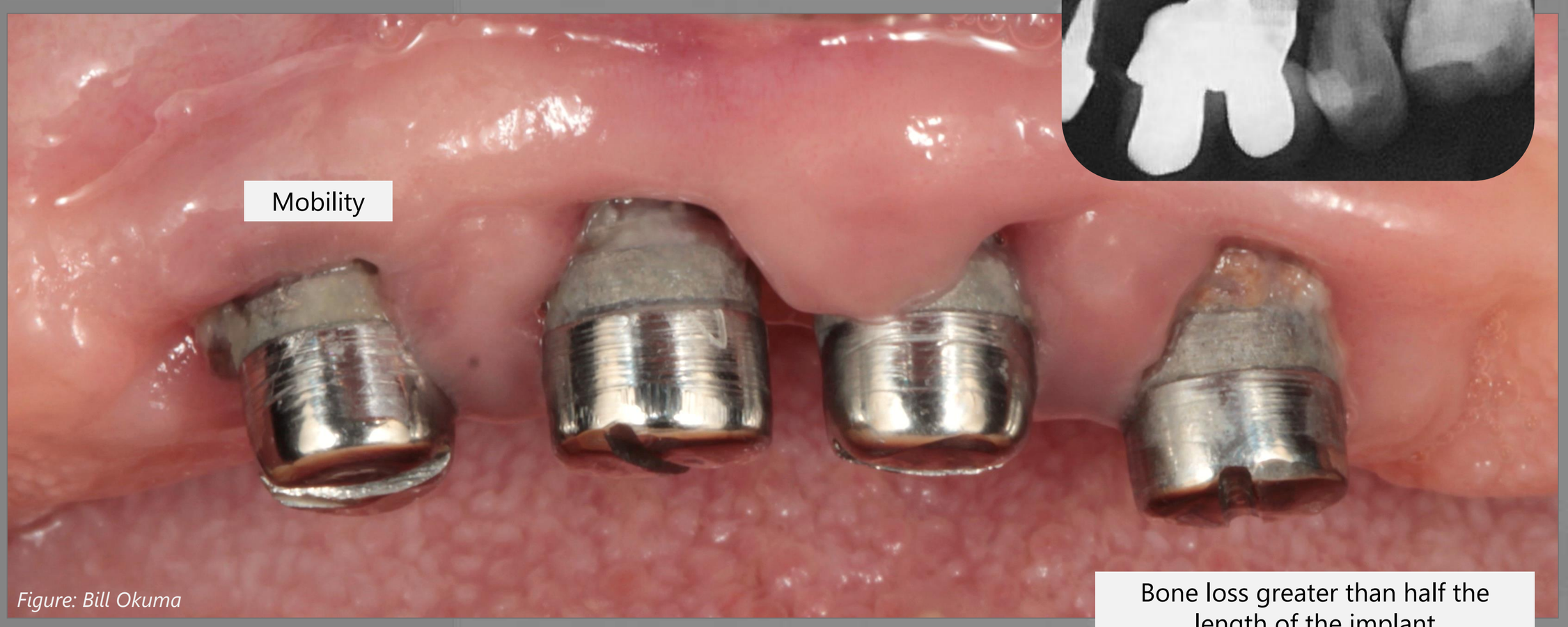


Figure: Bill Okuma

Bone loss greater than half the length of the implant

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