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Peri-Implant Mucositis: Current Evidence and Emerging Strategies for Prevention and Management

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Abstract
Peri-implant mucositis is a highly prevalent biofilm-associated biological complication that can directly threatens the long-term clinical success of dental implants. As a reversible inflammatory lesion confined to the surrounding soft tissue, it serves as a precursor to peri-implantitis causing progressive marginal bone loss. Clinical diagnosis relies on identifying indicators of soft-tissue inflammationsuch as erythema, edema, and bleeding on probing combined with radiographic monitoring to confirm the absence of bone loss. The development and progression of this condition are driven by some risk factors which include inadequate plaque control, smoking, diabetes, a history of periodontitis and a lack of supportive keratinized tissue.

I. Introduction

Dental implants have emerged as an important treatment in dentistry, because they offer a very successful tooth replacement method(Di Spirito et al., 2024). When supporting a dental prostheses, dental implants have a long-term survival rate that make them functional for long durations(Renvert et al., 2018). However, because functional implants and their restorations may experience biological and mechanical issues, this may affect longevity of this restoration(Derks et al., 2016).

Dental implants may give rise to three categories of complications: biological, which encompass soft-tissue issues, early implant failure, and peri-implantitis. Technical, including implant fractures, loosening or fracture of screws or abutments, loss of retention, fractures of veneering materials such as ceramics, framework fractures, and chipping. And aesthetic, such as chipping. Additionally, these complications can occur in combination(Pjetursson and Heimisdottir, 2018). Biological complications are characterized by inflammatory responses in the hard or soft tissues surrounding the implant, potentially leading to peri-implant mucositis or, if not addressed, progressing to peri-implantitis (Mancini and Health, 2022). However, prior to exploring peri-implant disorders and peri-implant mucositis in detail, it is essential to first grasp the criteria that define peri-implant health.

II. Search strategy:

To identify relevant literature for this review a comprehensive search strategy was executed across major electronic databases including PubMed, MEDLINE, Embase and the Cochrane library. The search protocol utilized a combination of Medical Subject Headings (MeSH) terms focused on core entities: "peri-implant mucositis", "dental implants", " prevention", "management", and "treatment".

III. Criteria of peri-implant health

For peri-implant tissues to be considered healthy, there must be no clinical indicators of inflammation, such as erythema or edema, and no bleeding upon probing(Renvert et al., 2018).The healthy peri-implant mucosa should look clinically comparable to healthy gingiva [Figure 1]. When the peri-implant sulcus is probed circumferentially using a light force of approximately 0.2 N, the site should show neither bleeding nor visible signs of inflammation, including erythema or oedema(Heitz-Mayfield, 2024).

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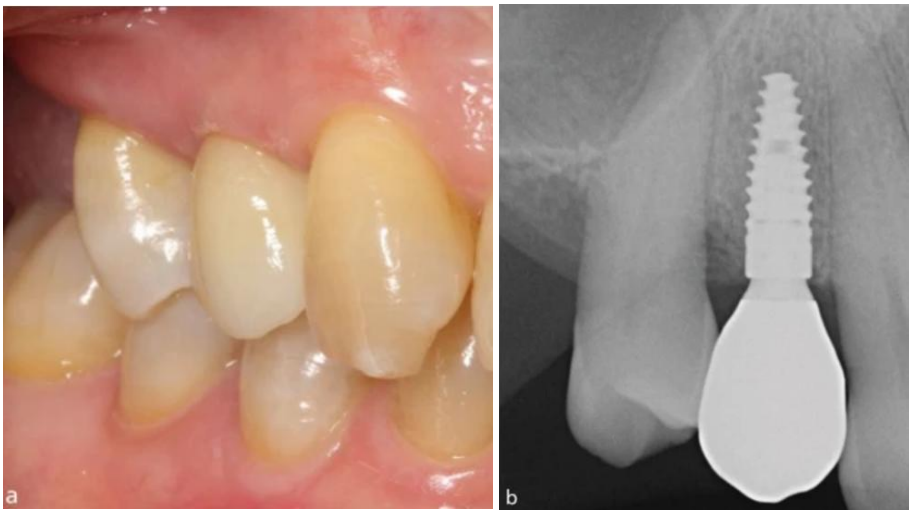

Figure 1: An implant-supported crown in the upper right first premolar region, showing peri-implant mucosa that is clinically and radiographically healthy(Heitz-Mayfield, 2024).

On average, healthy peri-implant mucosa measures roughly 3 - 4 mm in height. The coronal region of this mucosa, which faces the implant or abutment, is lined by a sulcular epithelium together with a thin junctional epithelium, whereas the more apical portion consists of connective tissue that lies in direct contact with the implant surface(Berglundh et al., 2018).

Healthy peri-implant sites harbour a distinct microbiota that differs considerably from the microbial population found in diseased peri-implant tissues(de Campos Kajimoto et al., 2024). The most frequently encountered peri-implant and periodontal infections have been grouped according to their association with periodontal health or disease into the so-called Socransky complexes, comprising the red, orange, yellow, green, purple, and blue groups(Di Spirito et al., 2024). The red complex is strongly linked to both peri-implantitis and periodontal disease. Bacteria of the orange complex typically appear before those of the red complex and are associated with the onset of periodontal disorders. The yellow complex is chiefly associated with health and plays a vital role in maintaining dental health. Purple complex bacteria are among the earliest colonizers of the biofilm and are also linked to periodontal health. Blue complex bacteria help sustain oral microbial homeostasis and are likewise associated with health(Socransky and Haffajee, 2005). In healthy periodontal sites, the microbial community is dominated by a broad range of bacteria, primarily Gram-positive facultative anaerobes such as Actinomyces species and Streptococcus [Figure 2](Di Spirito et al., 2024).

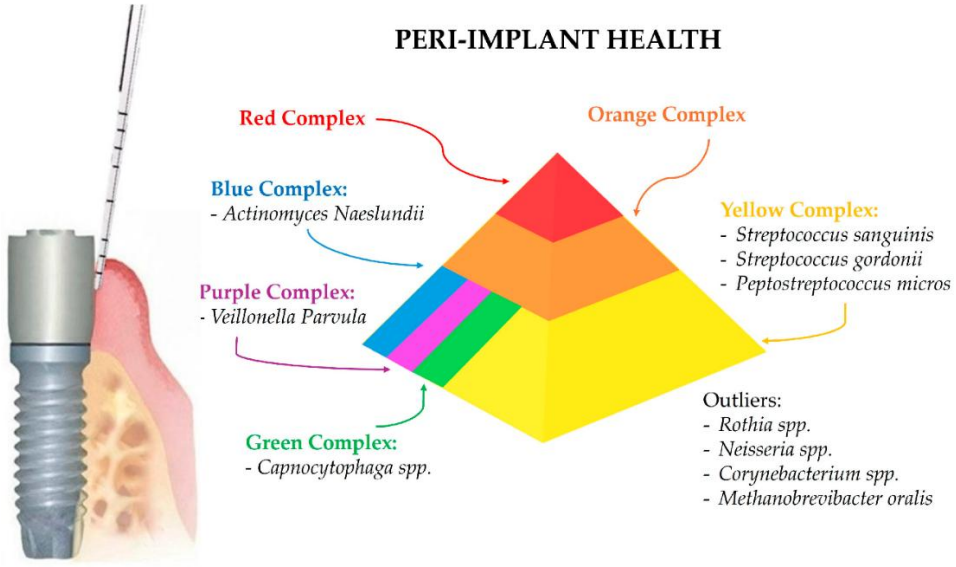

Figure 2: Socransky's microbial complexes associated with peri-implant health(Di Spirito et al., 2024).

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IV. Peri-implant diseases

Peri-implant disorders, also known as peri-implant diseases, are biofilm-driven inflammatory conditions affecting the tissues surrounding implants and encompass two entities: peri-implant mucositis and peri-implantitis(Heitz-Mayfield, 2024). At the first European Workshop on Periodontology (EWOP), peri-implantitis was defined as an inflammatory process accompanied by loss of supporting bone around a functioning implant, while mucositis was described as a reversible inflammatory reaction confined to the soft tissues surrounding a functioning implant [Figure 3](Lee et al., 2017).

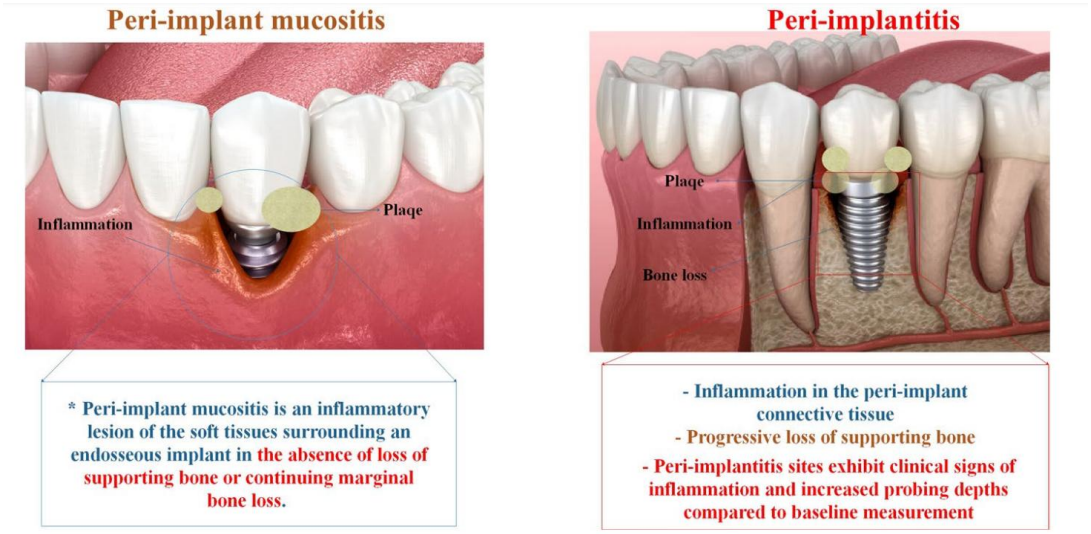

Figure 3: Distinction between peri-implant mucositis and peri-implantitis (Hosseini Hooshiar et al., 2024).

According to the American Academy of Periodontology, peri-implant mucositis involves inflammation of the soft tissues around dental implants without additional bone loss beyond the initial remodeling that may occur during post-surgical healing. A study describe peri-implantitis as inflammatory lesions of the mucosa surrounding endosseous implants, together with progressive loss of the supporting peri-implant bone [Figure 4] (Lee et al., 2017).

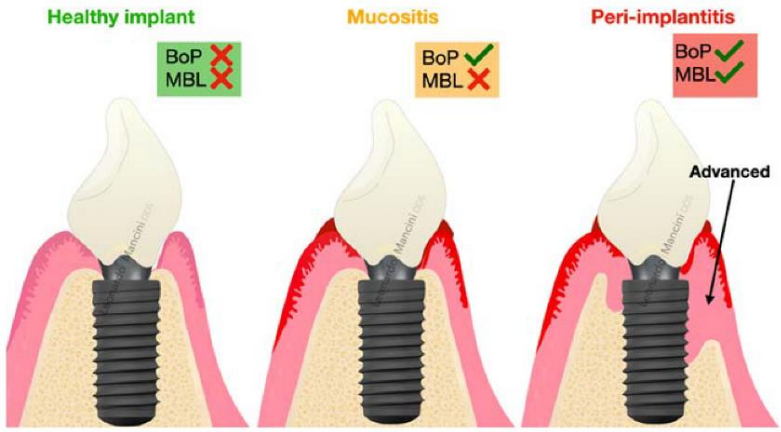

Figure 4: Main clinical differences between peri-implant health, mucositis, and peri-implantitis (BoP = bleeding on probing, MBL = marginal bone loss)(Mancini, 2022).

V. Diagnosis of peri-implant mucositis

The diagnosis of peri-implant mucositis should be based on clinical signs of inflammatory disease. During routine clinical examination, it is essential to look for evidence of inflammation. In addition, radiographic images must be evaluated to exclude changes in bone level (Renvert et al., 2018).

The key clinical indicator of inflammation is bleeding following gentle probing (0.2 N).Further signs may include redness, edema, and suppuration

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(pus). In the presence of peri-implant mucositis, probing depths around the implant may also be greater than the baseline measurements recorded after delivery of the implant prosthesis. When these clinical signs are identified during assessment, a diagnosis of peri-implant mucositis is confirmed provided that the radiograph shows no marginal bone loss [Figure 5] (Heitz-Mayfield, 2024).

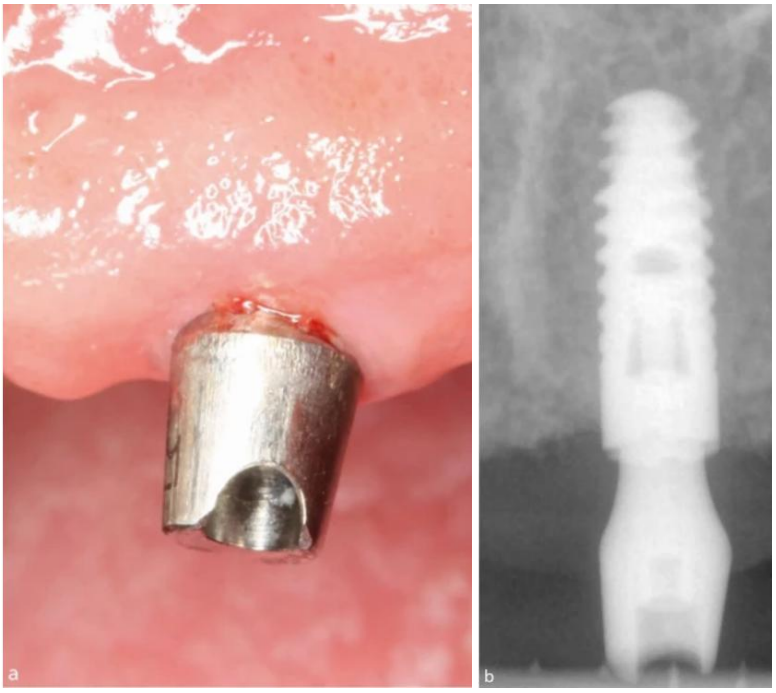

Figure 5: (a) Clinical and (b) radiographic views of an implant with peri-implant mucositis(Heitz-Mayfield, 2024).

It should be kept in mind that whenever clinical signs of inflammation are present, an intraoral radiographic evaluation of the bone levels around the implants should always be carried out(Renvert et al., 2018).

VI. Prevention of peri-implant mucositis

Effective prevention of peri-implant mucositis rests on careful management of the microbial biofilm around dental implants. This is achieved through a combination of meticulous home biofilm control and regular professional examinations. Alongside comprehensive oral hygiene instruction, which is essential for preventing peri-implant disorders, professional check-ups play a key role in detecting the condition at an early stage. Equally important is the consistent practice of home care routines tailored to each patient's individual needs(Romito et al., 2024).

6.1 Risk indicators and risk factors for peri-implant mucositis

Several well-established risk factors and risk indicators may contribute to the onset of peri-implant mucositis [Figure 7](Kormas et al., 2020). These include diabetes, smoking, exposure to radiation, and accumulation of microbial biofilm. The amount of keratinized tissue surrounding a dental implant is another key consideration, as insufficient keratinized tissue can substantially increase the risk of peri-implant mucositis(Romito et al., 2024).

Patient compliance is another important factor in maintaining implant health. Irregular prophylaxis has been associated with a greater likelihood of peri-implantitis developing (Dreyer et al., 2018). Moreover, patients with either a history of periodontitis or active periodontitis have been shown to be considerably more susceptible to peri-implantitis than those without the disease(Stacchi et al., 2016, Dreyer et al., 2018).

Conversely, a number of parameters have been identified as risk factors or risk indicators for peri-implant mucositis and peri-implantitis, yet findings across studies remain inconsistent. These include age, sex, implant location, implant surface characteristics, osteoporosis, and bone augmentation of the site before implant placement (Kormas et al., 2020). Whether keratinized tissue around the implant is present or absent is among the most debated factors in peri-implant disease, and the conflicting results reported in the literature prevent

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any firm, evidence-based conclusion from being drawn(Dreyer et al., 2018). Although the literature does not consistently support its necessity, a minimum of 2 mm of keratinized tissue is currently regarded as desirable(Kormas et al., 2020).

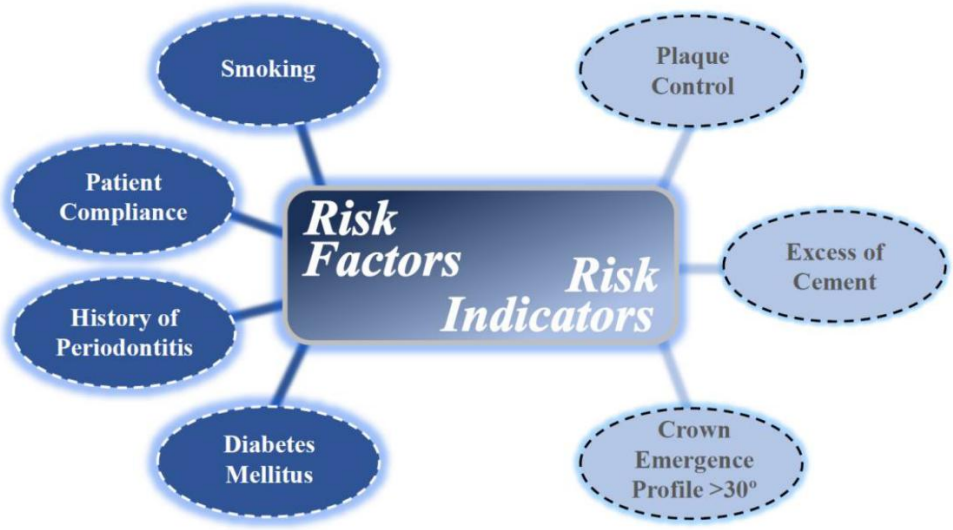

Figure 7: Risk factors and risk indicators that may contribute to the development of peri-implant mucositis and peri-implantitis(Kormas et al., 2020).

6.2 Home implant care

Many dental implant patients have a history of insufficient at-home care that ultimately led to a partially or fully edentulous state. In addition, these individuals may practice poor oral hygiene because they worry about damaging their teeth after surgery, or conversely, they may be excessively meticulous in trying to keep the mouth completely free of plaque. Either extreme can produce unfavorable outcomes. Therefore, to ensure the long-term success of the implants and the rehabilitation, oral hygiene instruction should include both detailed verbal guidance and visual demonstrations. Patients' oral hygiene techniques and tools should also be reassessed at every hygiene appointment. The implant care routine must begin as soon as the one-stage system is surgically placed, once the implant site is exposed in a two-stage system, and as soon as the healing screw becomes prematurely exposed in a two-stage system. During healing periods when mechanical plaque control is not yet appropriate, chemical agents such as chlorhexidine should be used instead(Gulati et al., 2014).

6.2.1 Brushing

Brushing options include soft manual toothbrushes, tapered rotary brushes, motorized toothbrushes, automated sonic toothbrushes, and end-tufted brushes. Implants should be cleaned twice daily with a soft toothbrush such as the Nimbus Microfine (Los Altos, Nimbus Dental, CA, USA) or a very gentle power brush to remove bacterial plaque accumulation (Goldstein et al., 2005). In addition, a motorized toothbrush such as the Rota-Dent (Professional Dental Technologies, Pro-Dentec, Inc., Batesville, AR), with its patented microfilaments, is nonabrasive to the abutment and very gentle on the tissues. It can be used together with a tapered brush to clean between teeth or to reach the underside of connector bars(Perel, 2001). Small, soft-bristled brushes should be used to teach patients to brush in a circular motion using the BASS technique. A power or sonic toothbrush is recommended for patients with limited dexterity(Gulati et al., 2014). Smaller toothbrush heads, including tapered rotary brushes or end-tufted brushes, may be suitable for hard-to-reach areas (Humphrey, 2006). It has been found that there is no discernible difference between using a water flosser and brushing by hand in terms of improving peri-implant health, suggesting that both approaches are beneficial(Araújo et al., 2024).

6.2.2 Interproximal cleaning aids

Dental floss is one of the most effective interproximal cleaning aids. Many types of floss are available for removing interproximal plaque around implants. Dental tapes, which come in a range of widths, are used to clean exposed abutments. The interproximal area should be taken into account when selecting interproximal brushes. Smaller interdental brushes are useful in narrower interproximal gaps, whereas larger spaces can be

adequately cleaned with proxy brushes. However, interproximal brushes with an exposed metal wire tip, or those used with excessive pressure, can easily scratch the titanium surface of the abutment. For this reason, interproximal brushes with a plastic-coated wire are generally recommended in implant cases. Site-specific application of chlorhexidine or other anti-infective solutions is preferable to rinsing, since it not only targets the area but also helps remove plaque, minimize staining, and reduce tartar buildup(Gulati et al., 2014).

6.3 Professional implant care

Implant care should involve the removal of any calculus or plaque during a hygiene visit. The nonporous titanium surface calculus that forms around implants is typically supragingival and tends to be softer than calculus adhering to a natural tooth(Goldstein et al., 2005). Stainless steel and other metallic instruments can roughen, scratch, or contaminate the implant–abutment interface, or cause galvanic reactions there, making the titanium surfaces more susceptible to bacterial plaque and calculus accumulation and increasing the risk of peri-implant inflammation. For these reasons, such instruments should not be used to scale or probe dental implants(Yen Nee et al., 2022).

Although plastic instruments leave behind residue, they are recommended for scaling implants because they cause negligible surface change. Gold-plated curettes and graphite reinforcement make plastic instruments more durable, sharpenable, and usable. Care must be taken when sharpening these gold-plated tools or using them on uneven surfaces, because the gold surface may crack or wear down, exposing the underlying alloy and leaving an undesirable surface. After the instrument is inserted, the blade should be closed against the abutment and opened past it, engaging the deposit apically with the stroke continuing coronally. Short working strokes and gentle pressure should be applied, depending on whether the deposit is positioned horizontally, obliquely, or vertically, to avoid damaging the sensitive peri-implant sulcus (Gulati et al., 2014).

VII.Management strategies for peri-implant mucositis

Non-surgical professional treatment combined with reinforcement of oral hygiene is considered the standard approach to managing peri-implant mucositis. Non-surgical management options include: mechanical debridement using special curettes or ultrasonic scalers, air-powder polishing, adjunctive diode laser therapy, adjunctive antimicrobial photodynamic therapy, adjunctive locally delivered antibiotics, adjunctive systemic antibiotics, and adjunctive probiotics(Ramanauskaite et al., 2021).

7.1 Curettes

Curettes made from a range of materials have been developed specifically for debriding implant sites. Steel curettes are not recommended for cleaning titanium implants because their surface hardness exceeds that of titanium. Titanium-coated curettes do not scratch the surface, since their hardness is similar to that of titanium. Carbon-fiber curettes remove bacterial deposits without damaging the implant surface because they are softer than the surface, although they break easily. Teflon curettes have been proposed for use alongside air-abrasive systems owing to their properties being comparable to those of carbon-fiber curettes. Among all curette types, plastic curettes are the most delicate and have the least debriding power [Figure 8] (Figuero et al., 2014).

Figure 8: Use of a titanium curette (left), and carbon-fiber, Teflon, and plastic curettes (right), respectively(Figuero et al., 2014).

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7.2 Ultrasonic scaler

Sometimes the prosthesis limits access for a curette.In such cases, deposits can be removed using a sonic scaler or an ultrasonic device fitted with a plastic sleeve [Figure 9] (Mann et al., 2012, Gulati et al., 2014).

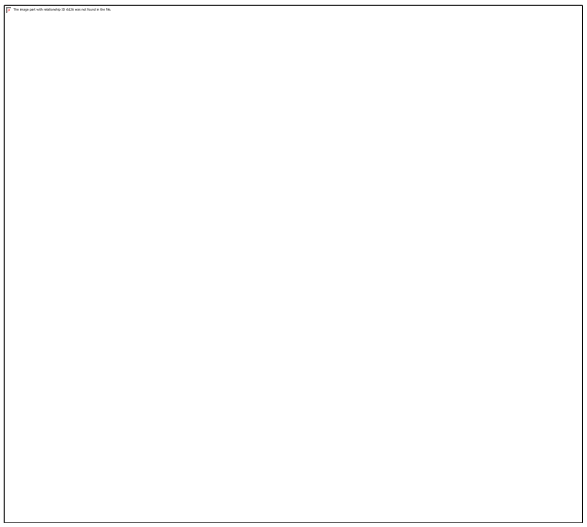

Figure 9: Conventional ultrasonic scaler tip (left) and a tip covered with a plastic sleeve(Mann et al., 2012).

Ultrasonic instruments with polyether-ether-ketone (PEEK) coated tips have been used to debride implant surfaces. The PEEK-coated tip is a modified tip with a stainless steel core. It is comfortable for the patient and readily debrides the implant surface. The purpose of this instrument is to remove calculus and plaque from the area around the abutment and implant neck, leaving a smooth, clean surface [Figure 10] (Figuero et al., 2014).

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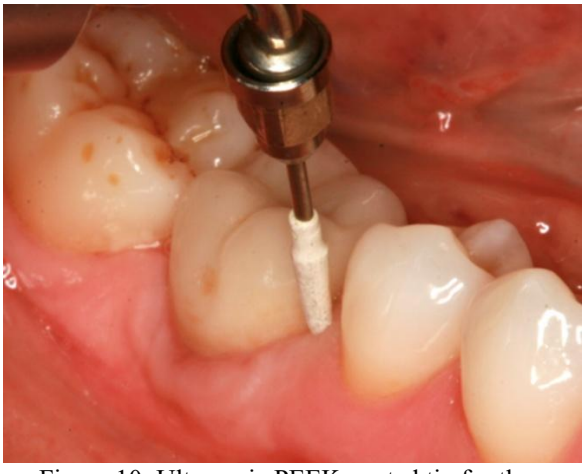

Figure 10: Ultrasonic PEEK-coated tip for the treatment of peri-implant mucositis(Figuero et al., 2014).

7.3 Air-powder polishing methods

Non-surgical approaches that use specific powders, such as sodium bicarbonate or the amino acid glycine, to remove biofilm from implant surfaces without the need for a surgical flap have been proposed as a treatment for peri-implant conditions, with favourable clinical and radiographic results(Boeira et al., 2021). Some studies support the use of air-powder abrasives while others oppose it. Compared with sodium bicarbonate, an air-powder abrasive containing the amino acid glycine had a lesser impact on the titanium implant surface (Yen Nee et al., 2022).

7.4 Lasers

A diode laser is a novel technique for cleaning titanium implant surfaces. However, surface damage caused by melting at the irradiation site was evident at higher energies of 4.5 and 5.5 W. Since the parameters evaluated showed no change to smooth or rough titanium implant surfaces, LED may be used to clean implants. Lasers such as Er:YAG alter both the rough and smooth surfaces of titanium implants. Other lasers, such as Nd:YAG, did not appear to alter the titanium implant surface in any way(Yen Nee et al., 2022).

7.5 Antimicrobial photodynamic therapy

This is an additional procedure used to clean dental implant surfaces or periodontal pockets. Reactive oxygen species and free radicals are generated when photosensitizers absorb laser light of a specific wavelength in the presence of oxygen. These methods decontaminate the peri-implant environment and provide antibacterial effects without the risk of resistance. This therapy is regarded as a safe and effective supplement to conventional mechanical debridement (Shahmohammadi et al., 2022).

7.6 Adjunctive use of locally delivered antibiotics

These have been used to prevent bacteria from colonizing the implant surface and to enhance the antibacterial effect of mechanical debridement. For the treatment of peri-implant mucositis, locally administered tetracycline has been applied to monolithic ethylene vinyl acetate fibers containing 25% tetracycline hydrochloride(Figuero et al., 2014).

VIII. Conclusion

The long-term viability of a dental implant depends on effective care and preventive strategies. Managing peri-implant mucositis relies on early detection and prompt action. By integrating patient-

centred care, evidence-based procedures, and routine monitoring, clinicians can extend the lifespan of dental implants and substantially reduce the incidence of peri-implant mucositis. Achieving the best outcomes requires a proactive, collaborative approach between patients and dental professionals.

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