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Peri-Implantitis Treatment Modalities: A Review

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ABSTRACT

Introduction: Implant dentistry was created to show reliable treatment approaches for restoring the oral cavity's esthetic and function. However, while dental implants have a high long-term success rate, dental implants are exposed to mechanical or biological complications. The therapeutic approaches will be addressed in this review.

Materials and Methods: Different data sources were used to conduct the literature search from 2010 to 2022 for treatment methods of peri-implantitis.

Results: In the study of the effect of laser, 16 items were selected for inclusion in this review. In the next step of study, we compared pre-implantitis treatment methods based on surgical and non-surgical methods without considering the drug method and finally 12 articles were included. In the final part of the study, we evaluated the effect of drug treatment on pre-implantation and 10 articles were included.

Conclusion: Peri-implantitis appears to be a multifactorial disease including the patient's host/microbe response, implant characteristics, soft tissue and the hard conditions surrounding the implant, and the dentist's surgical and prosthetic part experience. Different treatment modalities are present today, all are used to treat peri-implantitis, such as surgery, and laser therapy. Even though the different treatment modalities cannot be comparable, however, the outcome of surgical treatment of peri-implantitis is good. In peri-implant mucositis, non-surgical treatment seems to be sufficient. However, for the treatment of peri-implantitis, a surgical approach, which includes open-flap debridement, apically positioned flap and guided bone regeneration, is considered more appropriate.

Keywords: Peri-implantitis; Peri-implant mucositis; Dental Implant; Peri-implant surgical treatment.

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Introduction

Over the last decades, dental implants (DI) have been a commonplace approach to reconstructing partially or fully edentulous jaws [1]. They are considered successful treatments with a high rate of survival. Some criteria for implant success rate include 1. absence of radiolucency, pain, motion, and infection; 2. Bone resorption below 0.2mm annually; 3. Pocket probing depth (PPD); 4. Bleeding on probing (BoP) [2]. Implant failure risk is increased by periodontal disease and smoking [1].

The success of dental implant treatments has been confirmed in various studies [3]. However, evidence about treating peri-implant situations is inadequate [4]. Peri-implant disease is a non-specific inflammation in the host's tissue [5]. When the surface of the implants enters the contaminated environment of the mouth, a biofilm is formed on it. Similar to teeth, following the formation and development of microbial plaque, the immune system reacts, and peri-implant mucositis occurs [6]. The characteristic of mucositis is the presence of BoP and sulcus depth between 2-4mm [7]. Assuming that plaque accumulates further and remains stable for a prolonged period. In that case, it causes inflammation to spread from the mucosa around the implant to the apical side and alveolar bone degeneration [6].

Usually, bone destruction with a vertical pattern surrounds the implant and is called peri-implantitis (PI). However, in PI, the depth of the probe is usually more than 5 mm, and sometimes it is accompanied by pus secretion and alveolar bone destruction. However, clinical stability is still not compromised because the implant is not loosened [7]. Osseointegration is established in the apical parts of the implant. Since mucositis and PI are infectious, to prevent their occurrence, the follow-up program of the patient must be established precisely so that the health of the implants can be maintained throughout the person's life. In general, treatment should focus on infection and bacterial control because microbial biofilm plays a vital role in disease progression [8]. Treatment methods include surgical and non-surgical treatment. Several non-surgical treatments for PI include mechanical, chemical, antibiotic, antiseptic, laser, and photodynamic treatments. While non-surgical treatment may be a conservative treatment option, it has been shown to have a high recurrence rate, and often, the peri-implant disease does not resolve. Therefore, surgical treatment is often used to treat PI [9,10]. Surgical approaches for the treatment of PI include open-flap debridement (OFD), apically positioned flap (APF), and guided bone regeneration (GBR) [11,12]. If mucositis or PI is diagnosed during follow-ups, it should be treated according to the CIST protocol. CIST includes mechanical treatments, antiseptic and antibiotic therapy to control infection. Then, the created bone lesions are subjected to regenerative or resective treatment. It is clear that after the treatment, the patient should undergo preventive methods [13,14].

Materials and Methods

This research was a comprehensive review study, and the primary data collection method was searching four major databases, including Science Direct, Scopus, PubMed, and Google Scholar. The inclusion criteria for this literature review were Studies conducted from 2010-2022, which are English and full text is available. Systematic reviews and low-quality studies in the hierarchy of scientific evidence were excluded from the review (Figure 1).

Results

After searching the significant databases, 4762 articles were found in total. In the end, five papers for Er: YAG laser (Table 1), 11 articles for Diode laser (Table 2), six articles for surgical treatment, six articles for non-surgical treatment (Table 3), and ten articles for drug treatment (Table 4) and ten articles for drug treatment (Table 5) were included in the study. In the following tables, the required information was extracted.

Table 1. Use of Er:YAG laser in the treatment of PI.

Author (year)	*Intervention*	*Laser type and settings*
Renvert (2011) [15]	*Experimental group: Laser* *Control group:Air polishing*	*100 mJ/pulse*
Schwarz (2013) [16]	*Experimental group: Laser* *Control group : Plastic curettes*	-
Pommer(2016) [17]	*Group 1: Laser* *Group 2: Implantoplasty* *Group 3: Laser + implantoplasty*	*2.94 nm, 100 mJ/pulse*

Author (year)	Intervention	Laser type and settings
Wang (2020) [18]	Experimental group: Laser, and MD2 Control group: Surgical restorative treatment, MD and GBR.	50mJ/pulse, 25 pulse/s
Chen (2022) [19]	Experimental Group: : Laser Control Group: MD	100 mJ/pulse, 10 Hz, 100 μs

1 Randomized controlled trial.

2 Mechanical debridement.

Table 2. Use of diode laser in the treatment of PI.

Author (year)	Intervention	Laser type and settings
Schar (2013) [20]	Experimental group: PDT[1] Control group: Localized minocycline microspheres	Phenothiazine chloride dye 660 nm, 100 MW
Bassetti(2014) [21]	Experimental group: PDT Control group: Localized minocycline microspheres	Phenothiazine chloride dye 660 nm, 100 MW
Deppe(2013) [22]	PDT	Phenothiazine chloride dye 660 nm, 60 MW
Bombeccari (2013) [23]	PDT, and surgical treatment	800 nm, 1W (continuous mode)
Papadopoulos (2015) [24]	Laser, MD	980 nm, 0.8W (pulse mode)
Tenore (2020) [25]	Laser, MD	980 nm, 1W (pulse mode)
Mettraux (2016) [26]	Laser, MD(carbon fiber curettes)	810 nm, 2.5W, 50Hz, 10ms
Arisan (2015) [27]	Laser	810 nm, 1 W (pulse mode)
Yayli (2021) [28]	Group 1: Laser, MD Group 2:Er,Cr:YSGG+MD	940nm
Roccuzzo (2022) [29]	Laser, MD	810 nm, 2.5 W, 50 Hz, 10ms
Wawrzyk (2022) [30]	Laser	810nm, 3.84 W, 15.000 Hz, 10μs

[1] Photodynamic Therapy.

Table 3. Non-surgical studies.

Author (Year)	Treatment strategy
John (2015) [31]	First Group: AAD[1] Second Group: MDA[2]
Machtei (2012)[32]	First Group: MatrixC[4] Second Group: PerioC[5]
Jansaker (2017) [33]	First group: Local chloramine gel, Ultrasonic and manual tools Second group: Ultrasonic, manual tools
Sahm (2011) [34]	First group: AAD Second group: MDA
Heyman (2022) [35]	Resolvin D2
Khan (2021) [36]	First group: Oscillating chitosan brush Second group: Titanium curettes

1: Amino Acid Glycine Powder.

2: Mechanical Debridement with carbon curettes + Antiseptic therapy chlorhexidine.

3: Bleeding on probing.

4: Matrix Chips.

5: Chlorhexidine Chips.

6: Clinical attachment loss.

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Table 4. Surgical studies.

Author (Year)	Treatment strategy
Hentenaar (2017) [37]	First group: Resective surgery with apical flap, debridement with 35% phosphoric acid etching gel Second group: Resective surgery with apical flap, debridement with saline
Isehed (2018) [38]	First group: Bone regeneration with adjunctive EMD [1] Second group: Bone regeneration
Papadopoulos (2015) [24]	First group: Resective surgery with access flap, debridement with sterile gauze and plastic curettes soaked in the saline Second group: Resective surgery with access flap, laser diode, Plastic curettes
de Waal (2013) [39]	First group: Resective surgery with apical flap, debridement with 0.12٪ CHX 0.05٪ CPC [2] , Reconstruction of bone contour Second group: Resective surgery with apical flap, debridement, Reconstruction of bone contour
de Waal (2015) [40]	First group: Resective surgery with apical flap, Bone contour reconstruction, Debridement 2% CHX Second group: Resective surgery with apical flap, Bone contour reconstruction, Debridement 0.12% CHX 0.05% CPC
Monje (2022) [41]	First group: Reconstructive therapy with mixture of mineralized and demineralized allografts and cross-linked collagen membrane Second group: Reconstructive therapy with mixture of mineralized and demineralized allografts

[1] Enamel matrix derivative

[2] Cetylpyrinidium Chloride

Table 5. Drug treatments for PI.

Author (Year)	Antibiotics
Al-Deeb (2020) [42]	AZM [1]
Shibli (2019) [43]	AMX [2], MTZ [3]
Liñares (2019) [44]	MTZ
Nart (2020) [45]	MTZ
Hallström (2017)[46]	AZM
Jepsen (2016) [47]	AMX, MTZ
De Waal (2021)[48]	AMX, MTZ
Alqahtani (2021)[49]	AMX
Almohareb (2020)[50]	AMX, MTZ
Irshad (2021) [51]	AMX, MTZ

[1] Azithromycin.

[2] Amoxicillin.

[3] Metronidazole.

Discussion

Choosing an ideal replacement for tooth loss has been one of the main goals of the dental profession for many years. The use of implants has been very successful in the rehabilitation of edentulous patients. However, patients still suffer from the failure of the implant implantation process, which can be caused by biological or mechanical factors [52]. The mechanical bond created between the bone and the implant, as well as the biological acceptance of the implant by the bone tissue, is called osteointegration [52]. PI is a severe infectious disease after implant treatment, which affects both hard and soft tissues around the osseointegrated implant. This disease leads to bone loss around the implant site and subsequent loss of integrated bone. Inflammation of the gums only around the soft tissue of the dental implant, without any signs of bone loss, is called peri-implant mucositis. This condition is usually diagnosed by swelling and redness of the marginal tissue, mass formation, probing depth of more than 4 mm, bleeding during gum probing, bone loss, or pus secretion. Specific and continuous check-ups by evaluating and eliminating risk factors such as smoking, dental plaque, systemic diseases, and periodontitis are adequate precautions in dealing with PI [53].

There are various conservative and surgical approaches to treat peri-implant disease. In mucositis and moderate type of PI, it can be effectively treated using conservative methods, including the use of various manual ablations, laser-assisted systems, and photodynamic therapy, which may be effective in regaining osseointegration with local or systemic antibiotic administration [54]. In advanced cases of PI, surgical treatments are more effective. Depending on the structure of the defects, Access Surgery, which is primarily aimed at removing contamination from the implant surface, or resective surgery can be performed to remove lesions around the implant. At the same time, Regenerative Surgery may be necessary for filling the defects [55]. It is not possible to say with certainty which one of the methods is better or worse than the others for PI treatment [56]. Nevertheless, the most crucial principle and indicator of preventing this disease is to protect the implant surface from contamination [57]. Schwarz et al. [16] concluded that disinfection methods of implant surfaces did not affect the clinical results obtained with surgical treatment in the treatment of advanced PI disease. Renvert et al. [15] did not achieve statistically significant results in the air polishing and Er: YAG laser group. Unlike the previous study, Wang et al. [18] showed that the use of Er: YAG laser is effective in reducing PPD. In the study by Chen et al. [19], they concluded that mechanical debridement (MD) and Er: YAG laser are significantly effective for PI treatment. Besides, MD with ultrasonic scaler leads to a reduction in anaerobic bacterial count. Also, they mentioned that a combination of Er: YAG laser and MD is suggested for treating PI. Schar et al. [20] showed the positive effect of PDT, which may be an alternative treatment method in the non-surgical management of primary PI. Bassetti et al., [21] managed to show the effect of diode laser in eliminating mucosal inflammation. In the study by Deppe et al. [22], it was found that using a laser can stop bone resorption in moderate peri-implant defects, but it had no effect in severe defects. Tenore et al. [25] and Mettraux et al. [26] showed that the diode laser may adjunct conventional non-surgical treatments of peri-implant mucositis and primary PI. However, the results of the study by Arisan et al. [27] needed to be more consistent with the two previous studies regarding the effect of laser. In the clinical trial study by Yayli et al., [28] Er, Cr: YSGG laser was more efficient than diode laser 940nm at the clinical and molecular level for PI treatment. Besides, diode laser, in addition to MD, did not provide additional benefits. According to the study by Roccuzzo et al., [29] Diode laser, compared with MD, did not provide significant benefits. In an Ex-vivo study by Wawrzyk et al., [30] Diode laser 810nm was adequate to reduce Anaerobic bacteria and accelerate PI treatment.

In another study by Bombeccari et al., [23] it was found that laser therapy has less effect in reducing anaerobic bacteria on the uneven surfaces of implants than surgical treatment. In line with this study, we can mention the study of Papadopoulos et al. [24], who showed that the use of surgical methods is more effective in improving all clinical parameters than the additional use of diode lasers. The results obtained from this review supported the finding that administering systemic antibiotics such as metronidazole, amoxicillin, and azithromycin does not affect treating PI. After using these drugs, no change in BOP and PPD indices was observed in any of the studies. According to the studies, air abrasive devices and manual devices were effective in reducing PPD and increasing CAL (Clinical attachment loss). Also, air abrasive devices led to a statistically more significant reduction in BoP [16,31,34]. The additive effect of air abrasive devices over manual debridement is in removing bacterial plaque biofilms, which reduces the number of bacteria and leads to a lower BoP score [34]. According to the paper by Machtei et al., [32] PerioC decreased the

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mean PPD in MatrixC and increased CAL in the MatrixC group. Also, the significant improvement in the MatrixC group suggests that matrix degradation has an antibacterial effect. In a study by Heyman et al. [35], a new treatment modality, Resolvin D2 (RvD2), was used for PI treatment. RvD2 prevents alveolar bone loss around infected implants by reducing the invasion of neutrophils B-cells. Besides, it reduces lymphocytes, CD4+ cells, and Interferon-gamma secretion (IFN-γ).

In a clinical trial study by Khan et al. [36], the effect of Oscillating chitosan brush and titanium curettes was evaluated for PI treatment. Titanium curettes are a common approach for PI treatment. Both approaches had equal efficacy, and disease elimination could have been more predictable. Isehed et al. [38] concluded that using enamel matrix derivatives (EMD) positively correlates with implant survival. They also found that multiple treatments may be required to ensure a long-term sustainable outcome. Hentenaar et al. [37] compared 35% adjuvant phosphoric acid with resective treatment and saline disinfection. While they found that the experimental group experienced an immediate and significant suppression of the number of anaerobic bacteria on the implant surface, this did not translate into better clinical or even microbiological outcomes by the end of the next trimester. The authors hypothesized that surface damage to dental alloys may occur after detoxification with acidic solutions and prevent bone reintegration.

Similarly, de Waal et al., [39] found that a 0.12% chlorhexidine solution plus 0.05% CPC resulted in a more significant reduction of the bacterial load on the implant surface. They compared this with the results of Schwarz et al. [16], who showed that surface debridement and disinfection have no effect on clinical outcomes after combined surgical treatment of advanced PI lesions. The authors suggested that the long-term stability of clinical results may be influenced by factors other than the disinfection method. De Waal et al., [40] compared the effectiveness of 2% chlorhexidine solution versus 0.12% CHX and 0.05% CPC adjunct to resective surgical treatment. Despite both methods being practical, they found no significant differences between both groups on microbiological or clinical parameters. In a study by Monje et al. [41], reconstructive surgery with a mixture of mineralized and demineralized allografts clinically resolves PI and radiographically increases alveolar bone level. Besides, the use of a barrier membrane does not enhance the outcomes of treatment. According to studies, implantoplasty improved the results of non-reconstructive surgical treatment for PI and reduced the probing depth and the average BoP. Also, implantoplasty is effective in treating PI and should be considered. They concluded combining surgical access to the implant and tissue reconstruction is the most successful [58]. Fromm et al. [53] showed the efficacy of surgical reconstruction in PI and reduction of BoP for more than 3 to 7 years. Karalampakin et al. [59] found that surgical treatment was associated with a lower recurrence rate in PI cases. This means that PI is not only difficult to treat, but treated cases must be carefully monitored because recurrence is possible and common. In all proposed treatment methods, one of the critical steps is always decontaminating the implant surface.

Wohlfahrt et al. [60] evaluated porous titanium granules (PTG) along with an OFD method and MD of the implant surface for PI treatment. Both treatments significantly improved probing depth, but reconstruction with PTG resulted in better radiographic peri-implant defect filling. A study by de Waal et al. [39] showed that adjuvant benefits resulted from the addition of resective surgical treatment, including a flap with apical repositioning, bone re-contouring, and surface debridement and with CHX + 0.05% CPC 0.12% tends to suppress anaerobic bacteria on the implant surface more immediately than placebo solutions, but does not lead to superior clinical results. The treatment protocol is different depending on whether the mucositis is around the implant or peri-implant. Peri-implant mucositis can be treated non-surgically. If PI is diagnosed, the treatment protocol depends on the intraosseous defect. If the bone defect is minimal, implantoplasty can improve the bone defect. Implantoplasty requires absolute decontamination of the implant surface. However, there are four concerns in this field: creating heat, depositing the implant material in the surgical site, damaging the implant surface, and weakening the implant structure [61]. In implantoplasty, the roughness of the implant surface is removed on a microscopic and macroscopic scale, but this work is desirable and reduces the possibility of bacteria accumulation. Implantoplasty is considered an excellent complementary treatment for the decontamination of the implant surface and the treatment of PI lesions [62]. Non-surgical treatment can significantly improve clinical parameters, but bacterial pathogens are not reduced. The standard treatment of PI can be improved by reducing the bacterial pathogen if resective surgery is also effective in early cases of PI. In the advanced treatment of PI, the combined treatment of resective and restorative surgery, followed by surface disinfec-

tion, brings good bone integrity [16]. The present study showed that no statistically significant difference was found between laser therapy compared to conventional mechanical therapy in terms of reduction of postoperative PPD and increase in CAL. However, these results do not invalidate the efficacy of laser irradiation to obtain a reliable disinfection of infected implant parts and surrounding hard and soft tissue. In a recent study, the photo-sono-dynamic method through methylene blue loaded poly (D, L-lactide-co-glycolide) nanoparticles (MB loaded PLGA NPs) was effective against P. gingivalis. Besides, it did not cause deterioration in the implant surface and mechanical features of DI. This approach should be further used in clinical studies for the potential treatment of PI [63].

According to studies, laser, and photodynamic therapy techniques can produce significantly higher decontamination of anaerobic bacterial species compared to conventional treatment. In addition, biostimulation induced by laser radiation can stimulate faster peri-implant wound healing. Diode, Er: YAG and CO2 lasers showed better results in treating primary mucositis and PI after six months of follow-up. More extended follow-up periods showed that initial results were unstable, and cases of infection were re-described. However, the relapses that occur in the following months can be more due to poor hygiene by the patient than the ineffectiveness of the treatment. Also, using antibiotics administered systemically as a supplement to PI surgical interventions cannot be justified as part of a standard treatment protocol. According to the pathological pattern of PI, systemic antibiotics may be helpful as an adjunct to surgical treatment.

Conclusion

Achieving complete osseous integrity takes time and effort. Although different treatment methods are not comparable, the results of surgical treatment of PI are good. Surgical procedures for PI in humans have shown positive results, but long-term study is needed to achieve treatment reliability.

Conflict of Interest

There is no conflict of interest to declare.

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