

# The Impact of Periodontitis History on Implant Success Rates and Peri-Implant Health Parameters

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## Abstract

**AIM:** This study examines the effect of a history of periodontitis on implant success and peri-implant health, while evaluating maintenance therapies and the type of initial periodontitis.

**METHODS:** All longitudinal studies published between 2000 and March 2020, reporting partially dentate patients with treated periodontitis (chronic, moderate or severe) and accessible through Medline and Embase, were included. The evaluation and comparison of clinical parameters were performed for each study, focusing on implant success rate, implant survival, marginal bone level and loss, bleeding on probing, probing pocket depth, and overall periodontal status.

**RESULTS:** The search yielded 143 citations, of which 25 publications met the inclusion criteria. There was significant heterogeneity in study design, population, therapy, baseline definitions, and outcomes. The implant success rate was higher in periodontally healthy patients. However, patients with a history of periodontitis exhibited increased marginal bone loss and unfavourable periodontal parameters. Implant failure and biological complications were more common in patients with a history of severe periodontitis.

**CONCLUSION:** Dental implantation in patients with a history of periodontitis is associated with a higher incidence of peri-implant health complications and lower success rates compared with periodontally healthy patients. Severe periodontal disease and smoking are associated with higher implant failure rates. Factors such as gender, surgical procedures, surgical stages, implant location, loading protocol, implant brand and surface texture, and abutment type have minimal or no significant impact on peri-implant health.

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# 1 Introduction

Several high-quality studies have demonstrated that dental implants can successfully deliver predictable aesthetic and functional outcomes in more than 90% of cases (Goodacre et al., 2003). At the time this valuable treatment modality was introduced, clinical attention was focused primarily on the bone surrounding each implant and the achievement of osseointegration (Azari & Nikzad, 2008). However, in recent years, an increasing emphasis has been placed on the importance of so-called *dental implant complications*.

According to the *World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions*, clinicians are advised to obtain baseline radiographic and probing measurements after completing implant-supported prostheses (Berglundh et al., 2018). Biological complications following implant placement have become a major concern in contemporary dentistry. These complications are predominantly inflammatory in nature and are associated with bacterial challenge. It is now well established that peri-implant diseases, similar to periodontal diseases, result from a complex interaction between microbial biofilm and the host immune response (Berglundh et al., 2018).

An important finding of this consensus report is that dental plaque is the primary aetiological factor for peri-implant mucositis, while peri-implantitis is defined as a plaque-associated pathological condition characterised by inflammation of the peri-implant mucosa and subsequent progressive loss of supporting bone. Strong evidence indicates a higher incidence of peri-implantitis in patients with a history of chronic periodontitis, inadequate plaque control, and lack of regular maintenance care following implant therapy. Consequently, maintenance therapy has been strongly advocated as an effective strategy for improving plaque control and preventing the onset and progression of peri-implant diseases (Lin et al., 2020).

The prevalence of periodontitis has been extensively investigated, with reports indicating that approximately 50% of adults over 30 years of age and 68% of individuals older than 65 years are affected (Eke et al., 2015). Despite the similarities in clinical presentation and aetiology between peri-implantitis and periodontitis, notable histopathological differences exist between the two conditions (Berglundh et al., 2011). Specifically, differences have been identified in the inflammatory cell population, the location of inflammation, and the predominant cell types involved. In peri-implantitis, inflammatory infiltrates are located more apically compared to those observed in periodontitis (Berglundh et al., 2011).

Based on current consensus, a potential association between a history of periodontitis and the development of peri-implantitis has been suggested. However, it remains unclear which type of periodontitis—chronic or advanced—has a greater impact on dental implant success.

Therefore, the primary objective of this study is to evaluate the effect of a history of periodontitis on implant success rates and peri-implant health parameters. As secondary objectives, the study aims to assess the impact of maintenance therapy on reducing the prevalence of peri-implantitis and to investigate the influence of the initially diagnosed type of periodontitis (chronic or advanced) on implant outcomes.

## 2 Methods

The Population-Intervention-Comparison-Outcome-Study design (PICOS) structure for this review was as follows:

- P: Patients who had received dental implant treatment and had a previous history of periodontitis, either chronic or advanced.
- I: After implant loading, all patients were followed with regular post-treatment check-ups.
- C: The differences in implant survival rate and peri-implant clinical parameters (i.e., radiographic marginal bone loss (MBL), pocket depth (PD), bleeding on probing (BOP)) were evaluated between patients with and without a history of periodontitis.
- O: The primary outcome was the difference in survival rates at the implant level between the patients with a history of peri-implantitis and the patients without a peri-implantitis history.
- S: Clinical, randomized controlled, cohort, or multicentre studies in human patients.

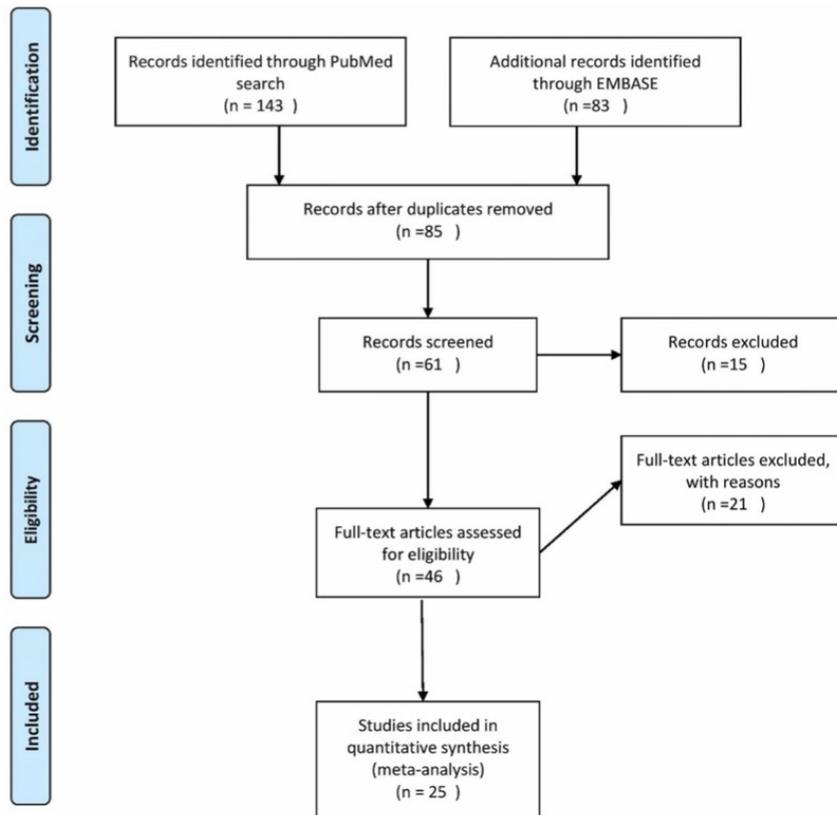
The inclusion criteria were all studies on treated patients with modern endosseous titanium dental implants, based on a previous history of periodontitis, independent of implant number, length, diameter, position, or angulation, with either screw-retained or cement-retained prosthodontic rehabilitation, according to a multidisciplinary loading protocol. All articles had to report at least the survival rate. Additionally, parameters analysing peri-implant health conditions, such as MBL, PD, and BOP, were extracted.

The exclusion criteria were articles published before 2000, non-English studies, and articles that could not be retrieved electronically. All studies with fewer than 20 patients were also excluded. Two major electronic databases, MEDLINE and EMBASE, were used to search for articles published from 2000 to March 2020.

The following search terms were used for search in MEDLINE: (((((((((((("dental implant") OR "dental implantation") OR "dental implantation endosseous") OR "implant supported dental prosthesis") OR "endosseous dental implantation")) AND ((Clinical Trial[ptyp] OR Controlled Clinical Trial[ptyp] OR Multicenter Study[ptyp] OR Randomized Controlled Trial[ptyp] ) AND ("2000/01/01"[PDat]:"2020/04/06 [PDat]) AND Humans[Mesh] AND English[lang]))) AND "periodontitis") AND ((Clinical Trial[ptyp] OR Controlled Clinical Trial[ptyp] OR Multicenter Study[ptyp] OR Randomized Controlled Trial[ptyp]) AND ("2000/01/01"[PDat]: "2020/04/06"[PDat]) AND Humans[Mesh] AND English[lang])))

For the Excerpta Medica database (Embase) by Elsevier the following search terms were utilised: ('dental implant':ab,ti OR 'tooth implantation' OR (endosseous AND dental AND implantation)) AND periodontitis AND ([controlled clinical trial]/lim OR [randomized controlled trial]/lim) AND [2000-2020]/py.

The electronic database searches yielded 143 titles from PubMed and 83 titles from EMBASE, respectively. The obtained hits were independently screened by title, and only studies based on human data were pre-selected, resulting in 61 publications for consideration. All remaining articles were then read in full text, resulting in the exclusion of 36 articles. These exclusions were mainly due to irregular or incomplete data, inclusion of information unrelated to the study objectives, or reporting on different topics such as teeth or drugs. The final 25 hits remained for consideration, which were all included for qualitative analysis (**Figure 1**)



**Figure 1.** Flow Diagram visualizing the study selection process according to PRISMA.

All relevant study characteristics, including information with respect to inclusion criteria, were extracted from each article based on study design; number of patients/implants; type of implants; smoking habits; implant insertion protocol; region of insertion in the mouth; history and type of periodontitis reported; treatment during implant insertion; and maintenance during follow up. The respective summary of the characteristics extracted is presented in supplementary **Table S1**.

For peri-implant health parameters, the following outcomes were extracted as the basis for the systematic analysis. The success/survival rate of implant treatment was the primary parameter of interest, and marginal bone loss (MBL), peri-implant probing depth (PPD), and bleeding on probing (BOP) were secondary outcome parameters.

The peri-implant clinical parameters extracted for analysis were: bleeding on probing (BOP); marginal bone loss (MBL); peri-implant probing depth (PPD); implant survival; and implant success.

Finally, the classification of periodontitis in the selected studies was assessed. The classification of periodontitis has changed over time and has been repeatedly modified (Caton et al., 2018). In the recent modification made by a World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions (Caton et al., 2018), three forms of periodontitis have been recognised: necrotizing periodontitis; periodontitis as a manifestation of systemic disease; and the forms of the disease previously recognised as “chronic” or “aggressive”, now grouped under a single category, “periodontitis”.

- Stage I: Initial periodontitis.
- Stage II: Moderate periodontitis.

- Stage III: Severe periodontitis with potential for additional tooth loss.
- Stage IV: Severe periodontitis with potential for loss of dentition.

Since all the articles included in the present study were conducted before the new classification was released in 2018, the two main categories of the previous classification were used in our study.

## 2.1 Statistics

Descriptive statistics, frequency analysis, and content analysis were employed as part of the qualitative methodology to systematically analyze the textual content of the included studies. It is important to note that, given the narrative nature of this study, regression analysis and meta-analysis techniques were not deemed suitable for the analytical framework.

## 3 Results

Of the 25 selected articles, four were multicentre studies, including prospective clinical trials with follow-up periods ranging from 1 to 5 years. Fifteen studies were conducted in a randomized controlled trial (RCT) format, with follow-up durations ranging from 16 weeks to over 9 years, and three studies used a pilot RCT design. Across the 25 prospective studies, a total of 17,495 implants from different brands were placed in 5,143 patients with treated periodontitis and 1,519 implants in 623 periodontally healthy patients. An overview of the relevant characteristics of the included studies is presented in **Table S1**.

Smoking and non-/light-smoking habits of participants were considered in several studies. Five studies exclusively included non-smoking participants, whereas seven studies did not address this factor. The remaining 13 articles included and analysed the impact of smoking status in their study design.

The protocols used for implant insertion may be classified as Immediate Insertion (Type I), Early Insertion (Type II), Delayed Insertion (Type III) and Late Insertion (Type IV) (Hämmerle et al., 2004). The included studies varied considerably with respect to insertion protocols, as presented in **Table S1**. Several differences were observed between studies regarding implant placement and loading protocols, including immediate, delayed and late loading. The surgical techniques used included both one-stage and two-stage procedures.

Different types of implants were reported in the selected studies. The main brands used were Brånemark, Straumann ITI, AstraTech, IMZ, Biomet, Camlog, Friadent, Sweden & Martina, Zimmer and Eurotechnik. The most relevant implant surface types were SLA, TiUnite, Osseotite, hydroxyapatite-coated and titanium plasma-sprayed (**Table S1**).

“Implant survival” refers to implants that remain in the mouth at the time of examination, regardless of the condition of the prosthesis or patient satisfaction, whereas “implant success” refers to implants that are not only present but also functional and satisfactory (Negm, 2016). Although these terms differ in meaning, as defined by Negm (2016), most selected studies used similar criteria to describe implant success. The success rate of implants inserted in patients with periodontitis ranged from 56.1% to 100% across the included studies. In some studies, success rates differed between the jaws, with the maxilla showing lower success rates than the mandible (Polizzi et al., 2000; Mengel & Flores-de-Jacoby, 2005). In one study, success rates were classified at both the implant and prosthesis levels (Wennström et al., 2004). All studies reported higher implant success rates for the

non-periodontitis group, ranging from 97% to 100%, compared with the treated periodontitis group, which ranged from 56.1% to 100%, over follow-up periods from 1 to more than 10 years (**Table 1**).

**Table 1.** Success rate of dental implants in reviewed studies.

STUDY	SURGICAL SETUP	SUCCESS RATE (%)
<b>Studies with Control Groups of Healthy Patients</b>		
Mengel (2005)	Late / 2 stage	Severe: Max 95.7, Man 100; Chronic: 100; Healthy: 100
Collaert (2008)	Delayed / 1 stage	Severe: 95.5; Moderate: 96.9; Healthy: 97
Gianserra (2010)	NR / NR	Severe: 95.6; Chronic: 96.9; Healthy: 97
Cecchinato (2011)	NR / NR	Periodontitis: 98.4; Healthy: 99.37
<b>Studies on Patients with History of Periodontitis (HOP)</b>		
Polizzi (2000)	Immediate / 2 stage	Post. Max: 88.9; Ant. Max: 94.2; Ant. Man: 95.1; Post. Man: 94.8
Wennström (2004)	2 stage	Subject: 94.1; FPD: 94.7; Implant: 97.3
Renvert (2007)	NR / 2 stage	100
Machtei (2007)	Immediate / 2 stage	83
Crespi (2010)	Immediate / 2 stage	Immediate: 87.5; Healed: 100
Deng (2010)	Immediate / 1 stage	100
Th1-Muhling (2010)	NR / NR	Smokers: 94.5; Non-smokers: 97.1
Ferrus (2010)	Immediate / 1 stage	100
Cavalcanti (2011)	NR / NR	Non-smokers: 97.1; Smokers: 94.5
Van Assche (2011)	Immediate / 2 stage	100
Costa (2011)	NR / NR	Maintenance: 82; Non-maintenance: 56.1
Quirynen (2011)	Immediate / 2 stage	100
Nicu (2012)	Immediate / 1 stage	95.8
Al Nashar (2015)	Immediate / 2 stage	78
Han (2015)	Immediate / 1 stage	95.8
Derks (2016)	NR / 2 stage	95.5
Blanco (2017)	NR / NR	100
Li (2018)	Immediate / 2 stage	Tur: 97.6; TiU: 100
Li (2018)	Immediate / 2 stage	NR
Raes (2018)	Delayed / 2 stage	NR

Maintenance therapy has been shown to be an effective method for achieving higher success rates (Costa et al., 2012). One study found no statistically significant relationship between smoking and implant success rates (Renvert et al., 2008). In contrast, a large multicentre study by Cavalcanti et al. (2011) reported that smokers were at a higher risk of implant failure than non-smokers; after 5 years of follow-up, smokers were approximately twice as likely to experience implant loss compared with non-smokers (5.5% vs. 2.9%). That study also reported success rates of 94.5% for smokers and 97.1% for non-smokers, with follow-up periods ranging from 16 weeks to 10 years.

Another study found that peri-implant bone loss was significantly greater in smokers than in non-smokers (Wennström et al., 2004). The adverse effect of smoking on marginal bone loss was also reported by Blanco et al. (2018). Similarly, Li et al. (2018a) demonstrated a negative impact of smoking on wound healing. However, one study questioned the role of smoking, concluding that it had no significant effect on implant success or marginal bone remodelling (Collaert & De Bruyn, 2008).

As depicted, the relationship between the HOP, in particular the type of periodontitis (chronic/severe), and peri-implant health parameters (MBL, BOP, PPD) was reported in detail and is presented in **Table S2**.

Marginal bone loss (MBL) was reported in several studies (Mengel & Flores-de-Jacoby, 2005; Ferrus et al., 2010; Polizzi et al., 2000; Quirynen et al., 2006; Machtei et al., 2007; Collaert & De Bruyn, 2008; Deng et al., 2010; Thöne-Mühling et al., 2010; Van Assche et al., 2012; Costa et al., 2012; Nicu et al., 2012; Al Nashar & Yakoob, 2015; Han et al., 2016; Blanco et al., 2018; Li et al., 2018a; Li et al., 2018b). There were several differences in the types and methods of measurement for bone-level changes, leading to results that are not directly comparable between studies. Sources of variation included differences in reference points due to the use of different implant systems, the standardization of the radiographic technique and differences in the baseline time point (for example, from time of insertion of the superstructure to 1 year after surgical implant placement).

Bone level changes around implants in the maxilla are significantly greater than those around implants placed in the mandible (Polizzi et al., 2000; Wennström et al., 2004). There were no statistically significant differences in reported MBL between chronic and advanced HOP. One study showed the positive effect of maintenance therapy on reducing MBL (Costa et al., 2012). In another study, a significant difference in MBL was reported between low and high abutment insertion (Blanco et al., 2018); at 3 and 6 months, implants with a 1-mm abutment had significantly greater bone loss compared with implants with a 3-mm abutment.

There were several differences in the methods of measurement for bleeding on probing (BOP), making the results incomparable between studies. Sources of variation included differences in reference points due to the use of different implant systems as well as differences in the baseline time point. The reported probing pocket depth (PPD) in the studies was also not standardised and therefore not comparable. Based on the reported studies, three main categories were identified: less than 4 mm, 4–6 mm and over 6 mm (Derks et al., 2016; Polizzi et al., 2000; Wennström et al., 2004).

The effect of maintenance therapy on increasing the implant success rate has been demonstrated in one study (Costa et al., 2012). The absence of preventive maintenance in individuals with pre-existing peri-implant mucositis was associated with an increased incidence of peri-implantitis (Costa et al., 2012). Clinical parameters such as bleeding on peri-implant probing, periodontal probing depth and the presence of periodontitis were associated with a risk of developing peri-implantitis. In the presence of gingival inflammation in the form of mucositis or periodontitis, preventive maintenance and continuous monitoring of peri-implant clinical parameters are necessary (Costa et al., 2012).

As shown in **Tables S1, S2**, the types of periodontitis reported in the selected studies ranged from chronic to severe and even aggressive. In some selected studies the peri-implant health parameters were considered, but the results were not significant and no clear relationship could be found between the type of periodontitis and peri-implant health parameters (Mengel & Flores-de-Jacoby, 2005; Crespi et al., 2017). However, a statistical difference in terms of implant success rate was observed between the healthy group and the chronic or severe HOP groups (Collaert & De Bruyn, 2008; Cecchinato et al., 2012; Gianserra et al., 2010).

Different types of implants have been reported in the selected studies. The main brands used were Brånemark, Straumann ITI, AstraTech, IMZ, Biomet, Camlog, Friadent, Sweden & Martina, Zimmer and Eurotechnik. The most relevant surface treatments reported were SLA, TiUnite, Osseotite, hydroxyapatite-coated (HA-coated) and TPS (**Table S1**). The role of implant type (brand), implant length and abutment height were indicated in some studies. In one study no significant difference between different implant types was reported (Nicu et al., 2012). In another study, Quirynen and Van Assche (2012) noted that the

roughness of more modern implants did not influence biofilm formation during the first year of implant loading.

Smoking and no-/light-smoking habit characteristics of participants were considered in some studies. One study showed no statistically significant relationship between smoking and implant success rate (Renvert et al., 2008). It was reported that the chance of experiencing implant loss is about two times higher for smokers than for non-smokers (5.5% versus 2.9%) (Cavalcanti et al., 2011). In another study, peri-implant bone loss in smokers was significantly greater than in non-smokers (Wennström et al., 2004). The detrimental effect of smoking on marginal bone loss and its reinforcing effect were shown by Blanco et al. (2018). Li et al. (2018a) reported negative effects of smoking on wound healing. Other selected studies concluded that smoking has no significant effect on implant success or marginal bone remodelling (Collaert & De Bruyn, 2008; Crespi et al., 2017).

The effect of jaw location (maxilla/mandible) was considered in some of the selected studies. In a long-term 5-year RCT, Polizzi et al. (2000) showed that MBL in the maxilla is higher than in the mandible in a series of implant-treated patients with HOP. In other studies (Deng et al., 2010; Mengel & Flores-de-Jacoby, 2005), a higher implant failure rate for maxillary post-extraction sites was observed and different MBL values following extraction and healed form were reported. A long-term 9-year RCT (Derks et al., 2016) found that chronic/severe HOP were observed more frequently in the mandible, with a higher implant success rate than in the maxilla. In a recent study, Raes et al. (2018) concluded that partially edentulous patients were at higher risk of developing peri-implantitis.

The effect of surgical protocol (immediate/delayed/late) was examined in some studies. Crespi et al. (2010) noted that placement of implants in chronically periapical infected sites did not necessarily change MBL following two years. Machtei et al. (2007) concluded that patients with HOP who require immediate loading of dental implants require more attention; implant success rate in the immediately loaded group was 83%, which is lower than in the immediately restored group (96%). Crespi et al. (2010) reported that immediate placement of implants in patients with chronic HOP did not affect the marginal bone level of immediately placed implants. Immediate placement of implants in HOP cases should be undertaken with greater caution and meticulous pre-operative and post-operative monitoring (Machtei et al., 2007).

Several studies noted that marginal bone level differs between mesial and distal sites; in these studies the mesial bone level was significantly greater than the distal level.

## 4 Discussion

On discussing and advising patients about different treatment modalities, including implant therapy, it is essential for practitioners to have reliable information on long-term success rates (preferably at least a five-year follow-up and longer), given that patients expect this type of therapy to deliver satisfactory outcomes for at least this period. The main obstacle to gathering more reliable information is the limited number of studies with a follow-up of 10 years or more that present both success rates and the frequency of complications after dental implantation. Studies with long follow-up times typically report outcomes for a single implant brand or a single treatment modality, and the criteria for success vary considerably.

The major issues that make comparison of different studies difficult are the lack of consensus regarding success criteria, the diagnosis of peri-implant disease, the definition and reporting of periodontitis history, and the definition of technical and clinical complications.

Pjetursson et al. (2012) noted that, for a more scientific overview, studies on long-term outcomes in implant therapy should report success rates together with the incidence of complications.

Peri-implant diseases, like periodontal diseases, have been regarded as a complex interaction between bacteria and host defence (Berglundh et al., 2018). The 2018 consensus stated that “plaque is the main aetiological factor for peri-implant mucositis and peri-implantitis is a plaque-associated pathological condition occurring in tissues around dental implants, characterized by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting bone”. Therefore, it is reasonable to consider plaque-inducing factors as strong influences on peri-implant diseases.

A history of periodontitis may therefore affect implant success, and a thorough analysis of the available studies would help clinicians to draw conclusions regarding overall possible success rates and to obtain more detailed information on treatment options that could positively affect outcomes.

The goal of this review was to summarise the findings on success rates of studies fitting the inclusion criteria with respect to the general impact of a history of periodontitis and, in particular, additional factors such as implant system, smoking habits, implant location and the surgical protocol applied. However, the heterogeneity of the 25 included studies prevented a definitive conclusion from being drawn.

Nevertheless, taking the overall trends into account, implants placed in patients with a history of severe periodontitis exhibited lower success rates and increased marginal bone loss compared with the chronic periodontitis group or healthy patients (Mengel & Floresde-Jacoby, 2005; Ferrus et al., 2010). Direct comparison of bone-level changes cannot be confirmed precisely because of non-standard definitions of marginal bone loss, varied measurement and standardisation procedures, different or absent reference points, and heterogeneity in implant surgery and placement (e.g. bone augmentation, loading protocol, surgical technique, implant type and design), statistical analysis methods, and baseline and follow-up assessments, all of which make comparison very difficult.

These findings are in agreement with a cross-sectional study by Marrone et al. (2013), which reported a patient-level prevalence of peri-implantitis of 39.3% in patients with HOP. However, the number of included studies that included healthy control groups is very limited; hence, determining the effect of preoperative periodontal health on postoperative peri-implant health is difficult. The principal obstacles to reaching a clear conclusion on the effect of a history of periodontitis on peri-implant health parameters are the divergent, non-uniform and non-standardised reporting of peri-implant and periodontal health issues, including marginal bone loss (MBL), probing pocket depth (PPD) and bleeding on probing (BOP), which are necessary for evaluating implant therapy success.

The only factor that appears to have been analysed in a comparable manner across studies is MBL. Reported information on BOP is heterogeneous with respect to measurement methods and often lacks detailed explanation, and PPD measurements were also divergent with no standardised definition applied.

Reportedly higher success for implants placed in the anterior region of the jaw, and for mandibular implants compared with their maxillary counterparts, suggests that implant position influences peri-implant health. This may be because of greater difficulty maintaining adequate oral hygiene in posterior regions.

In addition, classifications of periodontal disease, the types of treatment performed and periodontal status during follow-up varied across the included studies. This underlines the

importance of maintenance or supportive periodontal therapy to reduce peri-implant MBL, BOP and PPD; this was reported in only one study (Costa et al., 2012).

Female patients predominated in almost all included studies. Periodontitis is a complex polymicrobial inflammatory disease that may affect more than 100 million people and is a partial cause of tooth loss. Interestingly, periodontitis has a higher documented prevalence in men than in women, suggesting possible sex/gender influences in disease pathogenesis (Ioannidou, 2017). Although none of the selected studies identified an association between these factors and peri-implant tissue health, the predominance of female patients is noteworthy. One study, however, concluded that sex or gender has no significant role in peri-implant health (Collaert & De Bruyn, 2008).

The impact of smoking, as a potential plaque-inducing factor, on implant success and peri-implant health has been noted in some included studies (Cavalcanti et al., 2011; Thöne-Mühling et al., 2010). Current evidence indicates that smoking alters the microbiome around teeth and implants and likely influences disease severity in smokers. This is consistent with a recent consensus report by Tonetti et al. (2018).

## Conclusions

Within the limitation of this systematic review and from the studies selected, it could be concluded that:

1. Dental implants placed in patients with a history of severe periodontitis may be associated with lower success rates than those placed in periodontally healthy patients; however, a higher incidence of peri-implant health complications cannot be confirmed.
2. Smoking may jeopardise peri-implant health parameters and lead to higher implant failure rates; however, within the limits of the selected studies, it cannot be regarded as a major influencing factor.
3. The implant position in the jaw may positively affect reported peri-implant health parameters: implants in the mandible have higher success rates than those in the maxilla, and those in the anterior maxilla have higher success rates than those in the posterior maxilla.
4. The effect of supportive maintenance therapy following implant surgery could not be determined in the selected studies.
5. Implant brand and/or surface texture have little or no meaningful effect on peri-implant health parameters.
6. The design of long-term prospective studies needs to be revised in the future so as to fulfil the requirements of the new definition of periodontal disease and to focus more on standardised measurement of periodontal health parameters and outcomes.

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## **Ethical approval**

No ethical approval was required for this study as it did not involve human participants, animal subjects, or sensitive data. This study falls under the category of data collection without participant identification.

## **Consent for publication**

Not applicable.

## **Authors' contributions**

The author(s) declare that all the criteria for authorship designated by the International Committee of Medical Journal Editors have been met. More specifically, these are: (a) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (b) Drafting the work or revising it critically for important intellectual content; AND (c) Final approval of the version to be published; AND (d) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## **Competing interests**

The author(s) declare that there are no competing interests related to this work.

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## References

- Al Nashar, A., & Yakoob, H. (2015). Evaluation of the use of plasma rich in growth factors with immediate implant placement in periodontally compromised extraction sites: A controlled prospective study. *International Journal of Oral and Maxillofacial Surgery*, *44*, 507–512.
- Albandar, J. M. (2014). Aggressive and acute periodontal diseases. *Periodontology 2000*, *65*, 7–12.
- Azari, A., & Nikzad, S. (2008). Computer-assisted implantology: Historical background and potential outcomes—a review. *The International Journal of Medical Robotics and Computer Assisted Surgery*, *4*, 95–104.
- Berglundh, T., Zitzmann, N. U., & Donati, M. (2011). Are peri-implantitis lesions different from periodontitis lesions? *Journal of Clinical Periodontology*, *38*, 188–202.
- Berglundh, T., Armitage, G., Araujo, M. G., Avila-Ortiz, G., Blanco, J., Camargo, P. M., Chen, S., Cochran, D., Derks, J., & Figuero, E. (2018). Peri-implant diseases and conditions: Consensus report of workgroup 4 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. *Journal of Periodontology*, *89*(Suppl. 1), S313–S318.
- Blanco, J., Pico, A., Caneiro, L., Nóvoa, L., Batalla, P., & Martín-Lancharro, P. (2018). Effect of abutment height on interproximal implant bone level in the early healing: A randomized clinical trial. *Clinical Oral Implants Research*, *29*, 108–117.
- Caton, J. G., Armitage, G., Berglundh, T., Chapple, I. L., Jepsen, S., Kornman, K. S., Mealey, B. L., Papapanou, P. N., Sanz, M., & Tonetti, M. S. (2018). A new classification scheme for periodontal and peri-implant diseases and conditions: Introduction and key changes from the 1999 classification. *Journal of Periodontology*, *89*(Suppl. 1), S1–S8.
- Cavalcanti, R., Oreglia, F., Manfredonia, M. F., Gianserra, R., & Esposito, M. (2011). The influence of smoking on the survival of dental implants: A 5-year pragmatic multicentre retrospective cohort study of 1727 patients. *European Journal of Oral Implantology*, *4*, 39–45.
- Cecchinato, D., Bressan, E. A., Toia, M., Araújo, M. G., Liljenberg, B., & Lindhe, J. (2012). Osseointegration in periodontitis-susceptible individuals. *Clinical Oral Implants Research*, *23*, 1–4.
- Collaert, B., & De Bruyn, H. (2008). Immediate functional loading of TiOblast dental implants in full-arch edentulous maxillae: A 3-year prospective study. *Clinical Oral Implants Research*, *19*, 1254–1260.
- Costa, F. O., Takenaka-Martinez, S., Cota, L. O. M., Ferreira, S. D., Silva, G. L. M., & Costa, J. E. (2012). Peri-implant disease in subjects with and without preventive maintenance: A 5-year follow-up. *Journal of Clinical Periodontology*, *39*, 173–181.
- Crespi, R., Capparè, P., & Gherlone, E. (2010). Fresh-socket implants in periapical infected sites in humans. *Journal of Periodontology*, *81*, 378–383.
- Crespi, R., Capparè, P., Crespi, G., Lo Giudice, G., Gastaldi, G., & Gherlone, E. (2017). Dental implants placed in periodontally infected sites in humans. *Clinical Implant Dentistry and Related Research*, *19*, 131–139.
- Deng, F., Zhang, H., Zhang, H., Shao, H., He, Q., & Zhang, P. (2010). A comparison of clinical outcomes for implants placed in fresh extraction sockets versus healed sites in periodontally compromised patients: A 1-year follow-up report. *International Journal of Oral and Maxillofacial Implants*, *25*, 103–109.
- Derks, J., Schaller, D., Håkansson, J., Wennström, J., Tomasi, C., & Berglundh, T. (2016). Effectiveness of implant therapy analyzed in a Swedish population: Prevalence of peri-

- implantitis. *Journal of Dental Research*, *95*, 43–49.
- Eke, P. I., Dye, B. A., Wei, L., Slade, G. D., Thornton-Evans, G. O., Borgnakke, W. S., Taylor, G. W., Page, R. C., Beck, J. D., & Genco, R. J. (2015). Update on prevalence of periodontitis in adults in the United States: NHANES 2009 to 2012. *Journal of Periodontology*, *86*, 611–622.
- Ferrus, J., Cecchinato, D., Pjetursson, E. B., Lang, N. P., Sanz, M., & Lindhe, J. (2010). Factors influencing ridge alterations following immediate implant placement into extraction sockets. *Clinical Oral Implants Research*, *21*, 22–29.
- Gianserra, R., Cavalcanti, R., Oreglia, F., Manfredonia, M. F., & Esposito, M. (2010). Outcome of dental implants in patients with and without a history of periodontitis: A 5-year pragmatic multicentre retrospective cohort study of 1727 patients. *European Journal of Oral Implantology*, *3*, 39–45.
- Goodacre, C. J., Bernal, G., Rungcharassaeng, K., & Kan, J. Y. (2003). Clinical complications with implants and implant prostheses. *Journal of Prosthetic Dentistry*, *90*, 121–132.
- Hämmerle, C. H., Chen, S. T., & Wilson, T. G., Jr. (2004). Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. *International Journal of Oral and Maxillofacial Implants*, *19*, 26–28.
- Han, J., Zhang, X., Tang, Z., Zhang, L., Shi, D., & Meng, H. (2016). A prospective, multicenter study assessing the DENTSPLY Implants, OsseoSpeed™ TX, length 6 mm in the posterior maxilla and mandible: A 1-year follow-up study. *Clinical Oral Implants Research*, *27*, 452–457.
- Ioannidou, E. (2017). The sex and gender intersection in chronic periodontitis. *Frontiers in Public Health*, *5*, Article 189.
- Li, P., Zhu, H., & Huang, D. (2018a). Autogenous DDM versus Bio-Oss granules in GBR for immediate implantation in periodontal postextraction sites: A prospective clinical study. *Clinical Implant Dentistry and Related Research*, *20*, 923–928.
- Li, X., Tang, L., Lin, Y. F., & Xie, G. F. (2018b). Role of vitamin C in wound healing after dental implant surgery in patients treated with bone grafts and patients with chronic periodontitis. *Clinical Implant Dentistry and Related Research*, *20*, 793–798.
- Lin, C.-Y., Chen, Z., Pan, W.-L., & Wang, H.-L. (2020). Is history of periodontal disease still a negative risk indicator for peri-implant health under supportive post-implant treatment coverage? A systematic review and meta-analysis. *International Journal of Oral and Maxillofacial Implants*, *35*, 117–126.
- Machtei, E. E., Frankenthal, S., Blumenfeld, I., Gutmacher, Z., & Horwitz, J. (2007). Dental implants for immediate fixed restoration of partially edentulous patients: A 1-year prospective pilot clinical trial in periodontally susceptible patients. *Journal of Periodontology*, *78*, 1188–1194.
- Marrone, A., Lasserre, J., Bercy, P., & Brex, M. C. (2013). Prevalence and risk factors for peri-implant disease in Belgian adults. *Clinical Oral Implants Research*, *24*, 934–940.
- Mengel, R., & Flores-De-Jacoby, L. (2005). Implants in patients treated for generalized aggressive and chronic periodontitis: A 3-year prospective longitudinal study. *Journal of Periodontology*, *76*, 534–543.
- Negm, S. (2016). Implant success versus implant survival. *Dentistry*, *6*, 1000.
- Nicu, E. A., Van Assche, N., Coucke, W., Teughels, W., & Quirynen, M. (2012). RCT comparing implants with turned and anodically oxidized surfaces: A pilot study, a 3-year follow-up. *Journal of Clinical Periodontology*, *39*, 1183–1190.
- Pjetursson, B. E., Thoma, D., Jung, R., Zwahlen, M., & Zembic, A. (2012). A systematic

- review of the survival and complication rates of implant-supported fixed dental prostheses after a mean observation period of at least 5 years. *Clinical Oral Implants Research*, 23, 22–38.
- Polizzi, G., Grunder, U., Goené, R., Hatano, N., Henry, P., Jackson, W. J., Kawamura, K., Renouard, F., Rosenberg, R., & Triplett, G. (2000). Immediate and delayed implant placement into extraction sockets: A 5-year report. *Clinical Implant Dentistry and Related Research*, 2, 93–99.
- Quirynen, M., & Van Assche, N. (2012). RCT comparing minimally with moderately rough implants. Part 2: Microbial observations. *Clinical Oral Implants Research*, 23, 625–634.
- Quirynen, M., Vogels, R., Peeters, W., Van Steenberghe, D., Naert, I., & Haffajee, A. (2006). Dynamics of initial subgingival colonization of “pristine” peri-implant pockets. *Clinical Oral Implants Research*, 17, 25–37.
- Raes, M., D’Hondt, R., Teughels, W., Coucke, W., & Quirynen, M. (2018). A 5-year randomized clinical trial comparing minimally with moderately rough implants in patients with severe periodontitis. *Journal of Clinical Periodontology*, 45, 711–720.
- Renvert, S., Lindahl, C., Renvert, H., & Persson, G. R. (2008). Clinical and microbiological analysis of subjects treated with Brånemark or AstraTech implants: A 7-year follow-up study. *Clinical Oral Implants Research*, 19, 342–347.
- Thöne-Mühling, M., Swierkot, K., Nonnenmacher, C., Mutters, R., Flores-De-Jacoby, L., & Mengel, R. (2010). Comparison of two full-mouth approaches in the treatment of peri-implant mucositis: A pilot study. *Clinical Oral Implants Research*, 21, 504–512.
- Tonetti, M. S., Greenwell, H., & Kornman, K. S. (2018). Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. *Journal of Periodontology*, 89(Suppl. 1), S159–S172.
- Van Assche, N., Coucke, W., Teughels, W., Naert, I., Cardoso, M., & Quirynen, M. (2012). RCT comparing minimally with moderately rough implants. Part 1: Clinical observations. *Clinical Oral Implants Research*, 23, 617–624.
- Wennström, J. L., Ekstube, A., Gröndahl, K., Karlsson, S., & Lindhe, J. (2004). Oral rehabilitation with implant-supported fixed partial dentures in periodontitis-susceptible subjects: A 5-year prospective study. *Journal of Clinical Periodontology*, 31, 713–722.