BAOJ Dentistry

Barzanji,et al. BAOJ Dentistry 2018, 4: 3
4: 045

Review

Impact of Smoking as a Risk Factor for Dental Implant Failure: A Critical Review

Barzanji SA, Chatzopoulou D, Gillam DG

Institute of Dentistry, Barts and the London School of Medicine and Dentistry QMUL, London, E1 2AD, UK

Abstract

Introduction

There are numerous studies in the published literature that report on the increased risk of implant complications and failure in patients who smoke. An association between dental implants, grafting procedures (e.g. bone grafts maxillary sinus augmentation) and smoking history has been reported in the literature. Cigarette smoking may adversely affect wound healing and thus, jeopardize the success of bone grafting and dental implantation.

Aim

The aim of the present study was to conduct a critical review to evaluate the effects of a dose dependent impact of smoking on the success or failure of dental implants.

Method

A systematic search of the electronic databases and subsequent hand searching of the relevant articles published in English was performed and resulted in 60 papers. Of the 60 papers identified by this process, only eight studies were included in the review, based on the inclusion and exclusion criteria.

Results

The included studies compared the effects of smoking on both marginal bone loss and implant failure. Four out of five studies reported a strong correlation between smoking and an increased risk of implant failure. However, only two of the four studies reported on whether the risk of implant failure was affected by the quantity of daily cigarette consumption. Furthermore, of the three studies that analysed the effect of smoking on marginal bone loss, only two studies reported an increase in bone loss in smokers. None of the included studies demonstrated any correlation between smoking dose and increased marginal bone loss around a dental implant. The results suggested that there are limited evidenced-based data regarding the establishment a relationship between the quantity of cigarette consumption (in terms of smoking dose) and its effect on dental implant failure. There appeared to be limited data on clinical dental implant protocols regarding the acceptance of smokers in terms of a dose-related risk when considering patient suitability for implant placement.

Conclusions

The results from these studies included in the present review would therefore emphasize the importance of a patient's smoking status and the necessity of assessment and their ability to comply with professional recommendations, including oral hygiene instructions, prior to any implant treatment planning procedure. The patient should also be advised of the possibility of a poor prognosis following implant placement in patients who smoke, particularly in the maxillary region and in advanced surgical techniques e.g., sinus lift or bone regeneration.

***Corresponding Author:** David Gillam, Oral Bio Engineering Institute of Dentistry Barts and the London School of Medicine and Dentistry QMUL, London EA1 2AD, UK, E-mail: d.g.gillam@qmul.ac.uk

Sub Date: August 13th, 2018, **Acc Date:** August 22nd, 2018, **Pub Date:** August 23rd, 2018

Citation: Barzanji SA, Chatzopoulou D, Gillam DG (2018) Impact of Smoking as a Risk Factor for Dental Implant Failure: A Critical Review. BAOJ Dentistry 4: 045.

Increasing the predictability of the success of dental implants, selecting the choice of implant type and minimising the risk of subsequent peri-implantitis are therefore important reasons why patients should be advised and encouraged to permanently stop smoking.

Introduction

There are numerous studies in the published literature that report on the increased risk of implant complications and failures in patients who smoke. An association between dental implants, grafting procedures (e.g. bone grafts, maxillary sinuses augmentation), and history of smoking has been reported [1-8]. Cigarette smoking may adversely affect wound healing and thus, jeopardize the success of bone grafting and dental implantation [5, 7]. Heat as well as the toxic by-products of cigarette smoking, for example, nicotine, carbon monoxide, and hydrogen cyanide, have been implicated as risk factors for impaired healing, and, therefore may affect the success and survival of the dental implant due to the complications that may arise following these surgical procedures [5, 7-9]. The present guidelines indicate that patients who smoke should be warned by the Dental Professional regarding the increased risk of implant failure in smokers [10-11]. There does not however, appear to be any report on the real effect of smoking in terms of a dose dependent effect, or whether there are any evidenced-based recommendations on the minimum number of cigarettes that a smoker can smoke without any major negative impact on the survival rates on dental implants.

Aim

The aim of the present study therefore was to conduct a critical review using established search criteria to evaluate the effects of a dose dependent impact of smoking on the success or failure of dental implants.

Method

Study selection criteria and type of study

Inclusion criteria

1) Systematic reviews, meta-analysis, randomized clinical trials, prospective or retrospective clinical studies, cohort studies or case-control studies that were published in English since 1993.

Exclusion criteria

1) Review papers and case reports were excluded from the review.

Participants

Inclusion criteria

1) Medically healthy patients who smoke, and are fully/partially edentulous and had implant placement.

2) Studies involving patients who smoke and that report on the quantity of smoking.

Exclusion criteria

1) Studies that reported on implant placement in medically compromised patients who smoked.

2) Studies that did not report on the quantity (dose) of cigarette smoking.

Types of Intervention

Inclusion Criteria

1) Single or multiple dental implant placement studies.

Exclusion Criteria

1) Studies reporting on mini implant placement.

2) Studies involving zygomatic implants were excluded.

Types of Outcome Measures

1) Studies that reported the outcome of implant therapy in both smoker and non-smoker patients as success, survival, failure or implant loss and bone loss around the implants.

Search Strategy

A computer-based literature search conducted in electronic databases from MEDLINE-PubMed, Cochrane library and NICE up to the 1st of August 2013. The combination of search terms was used: Dental implant/Dental implant success, survival, failure or loss/Peri-implantitis/Smoking, Cigarette, tobacco/Smoking cessation/Dose of smoking. Additionally, hand search of journals and references from previously published review articles and relevant publications was also conducted.

Method of Review and Study Selection

The titles identified during the initial electronic search from MEDLINE-PubMed, Cochrane library and NICE database were 382, 36 and 380 respectively. Additional hand searching of journal titles resulted in 11 articles. A review of the abstracts and titles was conducted by AB (postgraduate student) who then obtained copies of all the relevant studies where available. Two of the three reviewers (AB, DC & DG) subsequently determined the eligibility of the papers and data extraction. Any differences as to the inclusion or exclusion of the articles were resolved following discussion between AB, DC and DG. Fig.1 illustrates the screening and study inclusion process.

Quality Assessment of the Eligible Studies

The methodological quality of the studies included in the review was assessed according to the criteria of concealment of treatment allocation described in the Cochrane Handbook for Systematic Review of Intervention [12].The acceptance and rejection criteria for the inclusion of relevant studies for the present review was discussed between the three reviewers (AB, DC, & DG) prior to the collation of papers. Allocation concealment for each study was rated as belonging to one of three categories:

a) Adequately concealed (adequate methods to conceal allocation was described)

b) Concealment unclear (random allocation stated/indicated but the actual allocation concealment methods were not described or an apparently adequate concealment scheme was reported but there was uncertainty whether allocation was adequately concealed)
c) Inadequately concealed (an inadequate method of allocation concealment was described)

Blinding of study participants and investigators was also assessed as follows:

A: Double-blind (blind outcome assessment and use of placebo used)

B: Single-blind (a blind outcome assessment was stated and a placebo used)

C: Blinding indicated or reported (blind outcome assessment reported but there is information that leads to suspicious/uncertainty about whether the examination was blind).

Due to the very limited data all studies that reported on the quantity of cigarette smoking were accepted as eligible for review prior to acceptance based on the inclusion and exclusion criteria.

Data extraction

The following information was extracted from each study:

- Author's family name, year of publication and study type
- Details of participants, including number of patients and implants, patient's age, quantity of cigarette smoking
- Details of intervention including implant site and follow up period
- Details of outcome report.

Results

A systematic search of the electronic databases and subsequent hand searching of Journals and References of the relevant articles published in English resulted in 60 papers. Of these 60 papers only 8 studies were considered acceptable, based on the selected inclusion and exclusion criteria, and these were subsequently included in the present study.

Excluded studies

Following a full text consideration of all the eligible papers, seven studies were excluded for the following reasons: 1).Outcomes reported in medically compromised patients [13-14], 2) No control group [15], 3) Case series study [16] and 4) The number and/or quantity of cigarettes was not reported [17-19] (Fig. 1)

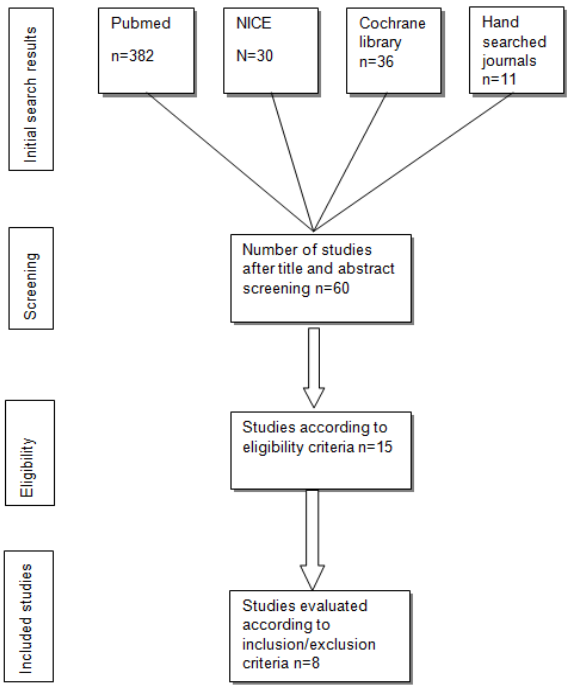

Figure 1 - Flow diagram outlining the processes of screening and inclusion of included papers.

Characteristics of Included Studies

The characteristics of studies meeting the inclusion criteria are summarized below in Table 1 [20-27].

Investigators	Study design	Follow up duration	Total Participant No.	Category of Study population	Number of participants in each group
Lindquist *et al.* [20]	Prospective	10 years	45	Non-smoker Smoking ≤14 cigarettes/day Smoking>14 cigarettes/day	Not specified for each group separately. (Smoker=21, non-smoker=24
Kan *et al.* [21]	Retrospective	2-60 month (Mean=41.6 months)	60	Non-smokers Smokers with low cigarette consumption <15/ day Smokers with high cigarette consumption ≥15 cigarettes/day	Not specified for each group separately. (smoker=16, non-smoker=44)
Schwartz-Arad *et al.* [22]	Retrospective	6 months	261	Mild smokers consumed <10 cigarettes per day Heavy smokers consumed >10 cigarettes per day	Not specified for each group separately. (smoker=89, non-smoker=172)
Feloutzis *et al.* [23]	Retrospective	2-7 years (mean=5.6 years)	90	Non-smokers (NS) Former smokers (FS) Moderate smokers (MS)=5-19 cigarettes per day Heavy smokers (HS) =20 cigarettes per day	NS=39 FS=23 HS=14
Gruica *et al.* [24]	Prospective	8-15 years	180	Non Smoker (NS) Former light smoker (FLS): Pa<20 cigarettes per day Former heavy smoker (FHS): ≥20 cigarettes per day Light smoker (LS): <20 cigarettes per day Heavy smoker (HS): ≥20 cigarettes per day	Not specified for each group separately (smokers=53; non-smokers=127)
Deluca *et al.* [25]	Retrospective	1-230 month (mean=59.8 months)	464	Non smoker Smoker ≤ 5 cigarettes per day Smoking 6-14 cigarettes per day Smoking≥15 cigarettes per day	Not specified for each group, separately at patient level
Noguerol *et al.* [26]	Retrospective	10 years	316	Non smoker Smoker of 1-10 cigarettes per day Smoker of 11-20 cigarettes per day Smoker of ≥20 cigarettes per day	Not specified for each group separately
Levin & Schwartz-Arad [27]	Retrospective	5 years	646	Non-smokers Past smokers Current smokers >5 cigarettes per day	N=49 N=5 N=6

Table 1: Characteristics of included studies

Analysis of the Included Studies

Study design and follow up duration

All the included studies were cohort studies, only two studies were identified as prospective studies [20, 24] and the remaining studies were retrospective studies [21-23, 25-27] (Table 1). No randomized clinical trials were however included for analysis in the present review. All the included studies reported variable follow up periods, for example from 1 month to 15 years. The duration of the follow up period of the 2 prospective studies ([20, 24] was 10 years and 8-15 years respectively whereas the duration of the follow up period for the retrospective studies varied from ≤ 6 months [22] to up to 15 years ([21, 23, 25-27]. (Table 1).

Study Population and Definitions of Smoker and Non-Smoker Groups

Each of the included studies used a different definition for the description of the smokers/non-smokers and this description varied from study to study, such as smokers, non-smokers, past smokers. For example, the studies by Lindquist et al. [2] and Levin & Schwartz-Arad [27] included participants in the non-smoker category if they reported that they never smoked, whereas DeLuca *et al.* [25] defined the non-smoker group as patients who either never smoked or who had stopped smoking one week before the implant placement and these investigators did not report any subsequent re-evaluation of the patients smoking status throughout the study. Kan *et al.* [21], Schwartz-Arad *et al.* [22], Noguerol *et al.*[26] failed to define the characteristics of the non-smoker group (Table 1). Furthermore, all these included studies had limitations in regard to the reported sample size in the smoker subgroups. For example, Levin & Schwartz-Arad [27] included only 6 patients categorized as a current smoker whereas 44 patients were included in the non-smoker group (Table 1).

Several of the included studies however, failed to include the number of patients in each of the groups [20-21, 26] or only presented the failure rates associated with the effects of smoking on an individual's implant level when a patient may have received multiple implants [25] (Table 1).

Randomization and Allocation Concealment

None of the included studies reported on the randomized patient allocation. Two of the included studies [23, 27] reported blinding of the assessor at the data analysis stage. Feloutzis *et al.* [23] was the only included study to report having a calibrated examiner.

Risk of Bias Assessment

There are four main domains that were used to assess the risk of bias for purposes of the present critical review. For example, allocation concealment, blinding of outcome assessor, incomplete outcome data and selective reporting. Only one study by Lindquist *et al.* [20] was identified as having a low risk of bias, two of the studies [23, 25] were identified as unclear and the remaining five included studies ([21-22, 24, 26-27]) were identified as having a high risk of bias.

Outcome Assessment Criteria and Statistical Analysis

There were differences in the collection of the outcome variables in each of the included studies and the data was presented in the studies used different statistical analysis (Table 2). For example, the different clinical outcomes included 1) marginal bone loss around an implant, 2) failure of the implant, 3) survival of the implant and 4) complication following implant placement (Tables 3-5). The heterogeneity in both the clinical outcomes and in the statistical techniques used to analyze the data from the included studies made a direct comparison of the results difficult (Tables 2-5). No meta-analysis was attempted in the present critical review.

Only three studies [21, 25-26] reported the clinical outcome, as "implant failure" although the criteria used to elucidate how the implant failed was different. For example, Kan *et al.* [21] used the Smith & Zarb [28] success criteria to determine implant failure whereas Noguerol *et al.*[26] reported implant failure when the implant was removed for any reason. DeLuca *et al.*[25] however, failed to report which implant failure criteria was used in their study. Schwartz-Arad *et al.* [22], reported that 'implant failure' was when the implant failed during the surgical phase and the implant was subsequently removed. Several of the included studies reported on the complications arising from implant placement, for example, in the study by Schwartz-Arad et al. [22] the reporting of the complications was divided into major and minor. A minor complication was when a spontaneous implant exposure without any surgical intervention occurred and a major complication was when there was a spontaneous implant exposure with a subsequent surgical procedure intervention (see Table 2).

DeLuca *et al.*[25] reported on both early and late implant failure based on the time of removal (before or after implant loading). The type of outcome assessment, criteria used for the assessment and reported statistical analysis is summarized in Table 2.

Investigators	Assessed outcome	Criteria	Reported statistical methods
Lindquist *et al.* [20]	Marginal bone loss	Radiographic bone level measurement	Student's *t* test, bivariable linear correlation, multiple linear regression, *P* value calculation for each variable
Kan *et al*. [21]	Implant failure	Smith & Zarb (1989) success criteria	Cumulative success rate, long rank test, chi-square test
Schwartz-Arad *et al.* [22]	Implant complication and failure	Self-described criteria	Analysis of variance test
Feloutzis *et al.* [23]	Peri-implant bone loss	Computerized radiographic bone level measurement	X^2 test, student's *t* test, multivariable linear regression, multivariate logistic regression, generalized estimating equation
Gruica *et al*. [24]	Per-implant bone loss and complication	Radiographic bone level measurement, Self-described criteria for biologic complication	Mean value, Mann-Whitney test (U-test), *P* value calculation, Bonferroni-Holm test
Deluca *et al*. [25]	Early and late implant failure and survival	Not specified	Relative risk (RR), odds ratio (OR), Proportional Hazard Regression (PH Reg), univariate and bivariate survival analysis,
Noguerol *et al.* [26]	Early implant failure	Implant removal due to any reason	Bivariate analysis, multivariate logistic regression analysis,
Levin & Schwartz-Arad [27]	Implant marginal bone loss, implant survival	Radiographic bone level measurement	Student's *t* test, cumulative survival rate

Table 2– Description of the clinical outcome, the criteria used and the type of statistical analysis conducted on the data collected from the included studies.

Description of the Results from the Included Studies: Effect of Smoking

Due to the heterogeneity of the various outcome reports from the included studies, only a comparison of the studies that reported on similar outcome measures will be compared in the following section. Lindquist *et al.* [20] reported a mean marginal bone (MB) loss of 1mm throughout their study the MB loss in smokers which was twice that of non-smokers in a 10 year follow up period (Mean=0.6 mm, P<0.001). Lindquist *et al.* [20] was the only study in the included studies to analyze the effect of oral hygiene measures in both the smokers and non-smoker groups. Although these investigators result failed to demonstrate any relationship between the oral hygiene status and MB loss in non-smokers, they reported on a significant effect of poor oral hygiene on MB loss (3 times more MB loss) in smokers group (P<0.001) when compared to the non-smokers group. Furthermore, a correlation coefficient analysis indicated that a patient who consumed (smoked) ≥14 cigarettes per day had poorer oral hygiene than an individual who smoked <14 cigarettes per day (P<0.01). The MB loss was reported to be statistically significant in smokers compared to non-smokers however the mean clinical the mean value was a 0.6mm MB loss in 10 years. A reported overall 1% failure rate in the non-smoker group was also reported in this study (Table 3).

Investigators	Effect of smoking on marginal bone (MB)	Overall failure rate	Smoker failure rate
Lindquist *et al*. [20]	MB loss greater in smokers and correlated with amount of cigarette smoking	1%	0%
Feloutzis *et al.*[23]	Greater MB loss in heavy smokers (>20 cigarette per day)	Not specified	Not specified
Gruica *et al*. [24]	No association	Not specified	Not specified
Levin & Schwartz-Arad [27]	Higher MB loss in current smokers	Two implant failure (no percentage report)	Not specified

Table 3– Reporting on peri-implant marginal bone loss in the included studies.

Feloutzis *et al.* [23] reported that heavy smokers (<20 cigarette per day) demonstrated a significantly increased marginal bone loss (mean=1.98 mm) (P<0.01) around the implants when compared to non-smokers (0.18 mm) and patients who stopped smoking (mean=0.24 mm). Gruica *et al.* [24] also reported that smoking has a significant effect on the marginal bone loss in patients with an IL-1 genotype, but smoking alone was not associated with any pei-implant bone loss (P=0.09). These investigators reported on a significant association between smoking and biological complications (p=0.0012), rather than MB level *per se.* Levin & Schwartz-Arad [27], observed a higher MB loss in current smokers when compared to former smokers or non-smokers (P=0.031). The reported cumulative survival rate analysis however failed to show any association between smoking habits and implant survival (Table 3).

Several investigators [21, 25-26] assessed the implant failure rate in their studies. For example, Kan *et al.* [21] used a cumulative success rate (CSR) analysis and reported that non-smokers had a significantly higher implant success rate (82.7%) when compared to smokers (65.3%) (P=0.027). The risk of failure in smokers was reported to be twice higher than in non-smokers however these investigators failed to demonstrate the smoking effect as being dose dependent. One should consider that all patients of this study had maxillary sinus graft that could potentially affect overall success and failure rate of implants. DeLuca *et al.* [25] also reported a significantly higher risk of early implant failure for a patient who was a smoker at the time of implant placement (3.6 % failure rate) and demonstrated that there was a direct relationship between the quantity of cigarette smoking and the implant failure rate.

Noguerol *et al.* [26] reported that there was a significant correlation between implant failure and smoking and patients who smoked >20 cigarettes per day had a significantly increased risk of implant failure (OR=2.5, Confidence intervals of 95%= 1.3-4.79) when compared to lower quantity smokers (Table 4).

Investigators	Non-smoker failure rate (percentage)	Smoker failure rate	Report of correlation between quantity of smoking and implant failure
Kan *et al*. [21]	7%	17.1%	No correlation
Deluca *et al*. [25]	13.33%	23.08%	Direct relationship between quantity of smoking and failure
Noguerol *et al.* [26]	4.2 %	11%	Direct relationship between quantity of smoking and failure

Table 4– Reported implant failure rate in the included studies

Schwartz-Arad *et al.* [22] assessed their study outcome based on the occurrence of complications (major and minor) and demonstrated a statistically significant difference between the complication rate in the smoking and non-smoking groups (P <0.05) (higher complication rates in smokers) although a dose dependent relationship was not evident.

Reported Surgical Procedures in the Included Studies

Five out of eight included studies did not report the use of a protocol for the surgical procedure that was conducted when placing a dental implant although three studies reported on the inclusion/exclusion criteria [22-23, 27]. Of those studies who reported using a protocol [22, 27] both studies used a surgical protocol described in previous studies by Schwartz-Arad *et al.* [29-32] and one study [25] reported using the 1985 Branemark protocol [33].

Five out of the eight included studies reported on the relationship between smoking and implant failure and 4/5 of these included studies demonstrated that smoking affected the implant failure rate. Nevertheless only 2/4 of the included studies [20, 26] reported that the negative effects of smoking on implant success/survival were dose dependent (Table 5).

Only three out of the eight included studies reported on the effect of smoking on the peri-implant bone loss, of these three studies only two studies [23, 27] demonstrated any direct relationship between smoking and increased marginal bone loss around the dental implant. None of these studies appeared to report any dose dependent relationship.

Investigators	Effect of smoking on implant failure	Dose dependent effect of smoking on implant failure	Reported number of cigarettes per day as cut-off point
Lindquist *et al*. [20]	+	+	>20 cigarette per day
Kan *et al*. [21]	+	-	-
Schwartz-Arad *et al*. [22]	-	-	-
DeLuca *et al*. [25]	+	-	-
Noguerol *et al*.[26]	+	+	>20 cigarette per day

Table 5 - Description of the relationship between smoking and implant failure reported in the included studies

Discussion

The evidence in the published literature regarding the adverse effects of smoking on the micro vasculature of the gingival tissue, host immune response, wound healing, and bone density would suggest that smoking may affect the implant outcome and that patients who smoke have higher rates of implant failures when compared to non-smokers [5, 7-9, 34]. However, there is a degree of controversy in the published literature with regard to the dose dependence adverse effects of cigarette smoking on implant treatment. There is also limited data on the application of a smoking cessation protocol prior to implant placement although there is some evidence that would suggest implementation of a protocol may reduce the negative effects of smoking on implant complications and failure [2, 9].

The evidence from both past and current published papers implicated smoking as one of the prominent risk factors affecting the success rate of dental implants with only a handful of studies failing to establish a connection. Most of the studies report on the failure rate of implants in smokers as being more than twice of that in non-smokers [5]. Smoking also been demonstrated to have a strong influence on the complication rates of implants following placement [5]. For example, there is significantly more marginal bone loss following implant placement and an increase in the incidence of peri-implantitis [5, 8]. It is therefore evident from the published literature that smokers have higher failure rates and complications following dental implantation and implant-related surgical procedures. From a practical viewpoint the clinician should advise their patients to follow a smoking cessation protocol, prior to any consideration of implant placement. For example, the initial recommendations by Bain and Moy [1] would appear to suggest that long periods of abstinence are required. In the first instance the patient should cease smoking for at least 1 week prior to the surgery to allow the reversal of the increased levels of platelet adhesion and blood viscosity, as well as the shorter-term effects associated with nicotine absorption. The patient should then continue to avoid tobacco for at least two months following implant placement, by which time the bone healing would have progressed to the osteoblastic phase and early Osseo integration would have been established [5]. One of the problems particularly when trying to alter any patient behaviour (particularly in smoking) is the resistance to any proposed changes that may be suggested by the clinician. Although this period of counselling may be perceived by some clinicians as unrealistic in terms of compliance it does have a biologic rationale. It should be acknowledged however that these early recommendations by Bain & Moy [1] have not been substantiated by any published clinical research data.

The aim of the present study was therefore to conduct a critical review from the included studies investigating the effects of smoking and its quantity (in terms of daily consumption of cigarette smoking) on the outcome of dental implant success/failure. A secondary aim was to determine whether there are any evidenced-based protocols in the published literature that deal specifically with daily consumption of cigarettes as part of the inclusion/exclusion criteria prior to accepting a patient who smokes for implant placement. Eight studies were included for analysis in the present study. One of the problems experienced however when analysing data from the included studies was the heterogeneity in all the included studies for example variations in the study design, outcome measures etc., which made any direct comparison with the studies difficult to complete. An additional observation was that none of the included studies reported any risk assessment for their patients other than their smoking status. All the included studies were conducted on medically healthy individuals, only one included study reported that all the participants had a positive history of periodontitis [23].A further observation from the included studies was there was a lack of a uniform protocol used in order to record all the clinical variables in the studies. For example, studies that conducted marginal bone level measurements (and any subsequent changes) around the implants 20, 23-24, 27] reported using different methods of bone level measurements as well as different radiographic techniques. These differences may have a confounding effect on the reported end points and a subsequent comparison of these results with other included studies.

Only one study [21] used the success criteria as proposed by Smith & Zarb [28] to report on implant success/survival rates. The other seven included studies reported on the failure, complication or survival rate of the dental implant only.

The reporting of the use of a surgical protocol when placing an implant was not consistently reported in the included studies. Of those included studies that provided a surgical protocol none of the studies recorded details of the patient inclusion/exclusion criteria. Although all the included studies reported on the quantity of smoking in their respective test groups, these groups however included a relatively small sample size in the smoker subgroups. Furthermore, some of the investigators failed to report any outcome for each of the smoking subgroup separately reporting only the overall effect of smoking compared to the non-smoking group [22, 26-27]). Moreover, some of the studies only draw their conclusions in regard to the dose dependent detrimental effects of smoking on dental implants whereas the other studies either did not include the number of patients in each group (20-21, 26] or they only presented failure results based on the effects of smoking at the individual implant level which may not necessarily take into account of a participant receiving multiple implants [23, 25], Feloutzis *et al.* [23] also reported that heavy smokers (>20 cigarette per day) demonstrated a significantly increased marginal bone loss (mean=1.98 mm) (P<0.01) around the implants when compared to non-smokers (0.18 mm) and patients who stopped smoking (mean=0.24 mm). Additionally, all the participants in this study group had a previous history of periodontitis which could have affected the outcome results. Also in recording the oral hygiene status of patients these investigators used a full mouth bleeding on probing (BOP) score, which may not necessarily be a reliable measurement in patients who smoke since they had reduced gingival bleeding due to the effect of nicotine. Kan *et al.* [21] used a cumulative success rate (CSR) analysis and reported that non-smokers had a significantly higher implant success rate (82.7%) when compared to smokers (65.3%) (P=0.027). The risk of failure in smokers was reported to be twice higher than in non-smokers however these investigators failed to demonstrate the smoking effect as being dose dependent. Additionally, the included studies reported a variation in defining the groups, for example, smokers, past/former smokers and present smokers differently and it was evident when comparing the data from the included groups there was no universally agreed protocol used to accept a specific definition on the patient's smoking/non-smoking status. Furthermore, the definition used in the included studies to define patients who had stopped smoking was reported differently in each of the studies. None of the included groups reported any subsequent reassessment of the smoking status smoking during the study. None of the included studies evaluated clinical parameters to report the outcome or long-term assessment. For example, none of the included studies reported on the clinical parameters relating to peri-implant disease (peri-implantitis or peri-mucositis) and all the included studies were based on reporting failure (surrogate outcome) of the dental implant. Only one study by Lindquist *et al.* [20], reported on the patient's oral hygiene measures throughout the study and it was therefore evident from the data recorded in the other included studies that oral hygiene status was not considered as a variable risk factor that may affect the implant success outcome. Feloutzis *et al.* [23] was the only included study that reported on the blinding of the assessors and any calibration of the examiners. None of the other included studies reported on blinding either of assessors or participants. It was therefore evident that a high risk of bias was present in most of the included studies. Although the prospective studies in the included studies provide a higher level of evidence in comparison to the retrospective studies, nevertheless this type of study may have limitations due to the difficulty of blinding, and randomization is not possible. Additionally, a larger sample size or a longer follow-up period may be necessary to determine the true (actual) effects of smoking on implant success or failure. Furthermore, it is evident that well conducted randomized clinical trials are needed to establish stronger evidence on the dose dependent effect of cigarette smoking and dental implants.

Although smoking has not been regarded as a contraindication for implant placement, there appears to be no clear guidelines for clinicians with regard to a cut-off point of the daily cigarette dose for patients who smoke. Furthermore, there does not appear to be any evidence-based protocols for smoking cessation before and after implant surgery. One of the problems may be that the published studies did not establish an acceptable or agreed definition of smoker, former smoker and non-smoker in relation to implant therapy. Furthermore, there appears to be limited data in regard to the exposure, dose and duration of smoking and their effects on implant survival and success although an association between heavy smoking and implant failure is supported and highlighted in the published literature. This limitation may therefore present difficulties for clinicians in establishing a well-defined and sound protocol in regard to smoking when treating patients for implants.

The results of the present critical review reported that there was a problem with the heterogeneity present in the included studies, which made it difficult to compare the outcomes from these studies. Furthermore, it was not possible to determine an ideal cut-off point in terms of the quantity of daily cigarette consumption, for a smoker to be eligible for inclusion in a clinical study evaluating the success or failure of implant placement. The present study also highlighted that there were no evidenced based clinical protocols recommended for he the inclusion or exclusion of smokers.

Conclusions

The results from these studies included in the present review would therefore emphasize the importance of a patient's smoking status and the necessity of assessment and their ability to comply with professional recommendations, including oral hygiene instructions, prior to any implant treatment planning procedure. The patient should also be advised of the possibility of a poor prognosis following implant placement in patients who smoke, particularly in the maxillary region and

in advanced surgical techniques e.g., sinus lift or bone regeneration. Increasing the predictability of the success of dental implants, selecting the choice of implant type and minimising the risk of subsequent peri-implantitis are therefore important reasons why patients should be advised and encouraged to permanently stop smoking.

References

1. Bain CA, Moy PK (1993) The association between the failure of dental implants and cigarette smoking. Int J Oral Maxillofac Implants 8(6): 609-615.
2. Bain CA (1996) Smoking and implant failure-benefits of a smoking cessation protocol. Int J Oral Maxillofac Implants 11(6): 756-759.
3. Bain CA, Weng D, Meltzer A, Kohles SS, Stach RM (2002) A meta-analysis of machined surfaced and Osseotite implants evaluating the risk for failure in patients who smoke. Compend Contin Educ Dent 23(8): 695-706.
4. Heitz-Mayfield LJ, Huynh-Ba G (2009) History of treated periodontitis and smoking as risks for implant therapy. Int J Oral Maxillofac Implants 24 39-68.
5. Kasat V, Ladda R (2012) Smoking and dental implants. J Int Soc Prev Community Dent 2(2): 38-41.
6. Moy PK, Medina D, Diana; Shetty V, Aghaloo TL (2005) Dental Implant Failure Rates and Associated Risk Factors. International Journal of Oral & Maxillofacial Implants 20(4): 569-577.
7. Levin L, Schwartz-Arad D (2005) The effect of cigarette smoking on dental implants and related surgery. Implant Dent 14(4): 357-361.
8. Baig MR, Rajan M (2007) Effects of smoking on the outcome of implant treatment: a literature review.Indian J Dent Res 18(4): 190-195.
9. Twito D, Sade P (2014) The effect of cigarette smoking habits on the outcome of dental implant treatment. Peer J 2: 546.
10. Alani A, Djemal S, Bishop K, Renton T, RCS (2012) Guidelines for Selecting Appropriate Patients to receive Treatment with Dental Implants: Priorities for the NHS.
11. Alani A, , Bishop K, Renton T K. Djemal S (2014) Update on guidelines for selecting appropriate patients to receive treatment with dental implants: priorities for the NHS –the position after 15 years.BDJ 217 189-190.
12. Higgins JPT, Green S (2011) Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 The Cochrane Collaboration.
13. Alsaadi G, Quirynen M, Komarek A, van Steenberghe D (2007) Impact of local and systemic factors on the incidence of oral implant failures, up to abutment connection. J Clin Periodontol 34(7): 610-617.
14. Alsaadi G, Quirynen M, Komarek A, van Steenberghe D (2008) Impact of local and systemic factors on the incidence of late oral implant loss.Clin. Oral Impl. Res 19(7): 670-676.
15. Romanos GE, Nentwig GH (2008) Immediate Loading Using Cross-Arch Fixed Restorations in Heavy Smokers: Nine Consecutive Case Reports for Edentulous Arches. Int J Oral Maxllofac Implants 23(3): 513-519.
16. Sanchez-Perez A, Moya-Villaescusa MJ, Caffesse RG (2007) Tobacco as a Risk Factor for Survival of Dental Implants. J Periodontol 78(2): 351-359.
17. Mundt T, Mack F, Schwahn A, Biffar R (2006) Private practice results of screw-type tapered implants: Survival and Evaluation of Risk Factors. Int J Oral Maxillofac Implants 21(4): 607-614.
18. Testori T, Weinstein RL, Taschieri T, Fabbro MD (2012) Risk Factor Analysis Following Maxillary Sinus Augmentation: A Retrospective Multicenter Study. Int J Oral Maxillofac Implants 27(5): 1170-1176.
19. Urban T, Kostopoulos L, Wenzel A (2012) Immediate implant placement in molar regions: risk factors for early failure. Clin Oral Impl Res 23(2): 220-227.
20. Lindquist LW, Carlsson GE, Jemt T (1996) A prospective 15-year follow-up study of mandibular fixed prostheses supported by osseointegrated implants. Clinical results and marginal bone loss. Clin Oral Implants Res 7(4): 329-336.
21. Kan JY, Rungcharassaeng K, Lozada JL, Goodacre CJ (1999) Effects of smoking on implant success in grafted maxillary sinuses. J Prosthet Dent 82(3): 307-311.
22. Schwartz-Arad D, Samet N, Samet N, Mamlider A (2002) Smoking and Complications of Endosseous Dental Implants. J Periodontol 73(2): 153-157.
23. Feloutzis A, Lang NP, Tonetti MS, Burgin W, Bragger U, et al. (2003) IL-1 gene polymorphism and smoking as risk factors for peri- implant bone loss in a well-maintained population Clin. Oral Impl. Res 14(1): 10-17.
24. Gruica B, Wang H-Y, Lang NP, Buser D (2004) Impact of IL-1 genotype and smoking on the prognosis of osseointegrated implants. Clin. Oral Impl Res 15(4): 393-400.
25. DeLuca S, Habsha E, Zarb GA (2006) The effect of smoking on osseointegrated dental implants. Part I: implant survival. Int J Prosthodont 19(5): 491-498.
26. Noguerol B, Munoz R, Mesa F, de Dios Luna J, O'Valle F (2006) Early implant failure. Prognostic capacity of periotest: retrospective study of a large sample. Clin. Oral Impl Res 17(4): 459-464.
27. Levin L, Hertzberg R, Har-Nes S, Schwartz-Arad D (2008) Long-Term Marginal Bone Loss Around Single Dental Implants Affected by Current and Past Smoking Habits. Implant Dentistry 17(4): 422- 429.
28. Smith DE, Zarb GA (1989) Criteria for success of osseointegrated endosseous implants. J Prosthet Dent 62(5): 567-572.
29. Schwartz-Arad D, Samet N, Samet N (1999) Single tooth replacement of missing molars: A retrospective study of 78 implants. J Periodontol 70(4): 449-454.
30. Chaushu G, Schwartz-Arad D (1999) Full arch restoration of the jaw with fixed ceramo-metal prosthesis: Late implant placement. J Periodontol 70(1): 90-94.
31. Schwartz-Arad D, Chaushu G (1998) Full arch restoration of the jaw with fixed ceramo-metal prosthesis. Int J Oral Max-illofac Implants 13: 819-825.
32. Schwartz-Arad D, Chaushu G (1998) Immediate implant placement: A procedure without incisions. J Periodontol 68: 1110-1116.
33. Branemark PI (1985) Introduction to osseo integration. In: Tissue integrated Prostheses. Osseo integration in Clinical Dentistry (Eds. Branemark PI, Zarb G, Albrektsson T.) Quintessence, Berlin, Chicago, Tokyo 1-76.
34. Hinode D, Tanabe S-i, Yokoyama M, Fujisawa K, Yamauchi E, et al. (2006) The influence of smoking on osseointegrated implant failure: a meta-analysis. Clin. Oral Impl. Res 17(4): 473-478.