Review Article

Evidence-based analysis of the effect of smoking on osseointegrated implant outcome

ABSTRACT

The outcome of the osseointegrated implant is influenced by various conditions, one of which is smoking. Literature shows conflicting results for the association between smoking and implant success. Hence, the study was conducted to assess the effects of smoking on survival and marginal bone loss of osseointegrated implants. Literature search of published articles in Medline, Scopus, Ovid, and Journal of Web till June 2020 were analyzed for the determined outcomes. Revman 5.4 software was used for the analysis of the study. Of the 437 articles screened, nine were chosen for review and analysis. Meta-analytic results showed that implant success rate was better in nonsmokers than smokers (odds ratio = 0.43, 95% confidence interval = 0.26–0.72, $P < 0.0001$). Smoking habit does seem to affect the implant outcome of survival and marginal bone loss negatively.

Keywords: Bone loss, edentulism, implants, peri-implantitis, smoking tobacco

INTRODUCTION

Osseointegrated dental implants are proven successful in treating partial and complete edentulism. Various systemic and local factors influence on the osseointegration maintenance and bone healing.[1] Smoking is considered to be a significant risk factor with regard to implant failure. Smoking habit shows to influence osseointegration in the earlier stages, which is dependent on the surface of implants and individual host genetic responses. Smokers in contrast to nonsmokers have exhibited altered bone composition and structure.[2]

In the previous decade, the surface texture of implants is modified from being smooth to a kind of rough texture, which is expressed as an average roughness of the Sa value of 1–2 _m.[3] This concept has enhanced the implant to bone surface contact, even in smokers. A fluoride incorporated surface was developed in the year 2000, with a moderately rough surface having nanoscale topography.[4] Survival rate and bone remodeling are attributed to osseointegration bought upon by osteoblastic differentiation, platelet activation, surface thrombogenica, and osteoconductive characteristics.

Various studies have assessed smoking habits influencing implant success rates. While a few of them postulated that smoking can enhance the failure of osseointegrated implants, others were not able to arrive at a definitive conclusion. To date, no definite consensus has been arrived thus deterring clinicians to not make any decisions regarding informed clinical decisions while placing implants in smokers. This could be attributed to a variety of factors such as design variability, quality of studies reviewed, and nonspecificity of eligibility criteria. The element of heterogeneity has made it difficult to conclude. Hence, this evidence-based analysis was conducted to explore the effect of smoking on osseointegrated implants, answering the PICO question

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"Does smoking have any effect on the outcome associated with osseointegrated implants?"

MATERIALS AND METHODS

Protocol and registration

The PRISMA checklist of systematic reviews and meta-analysis was analyzed for each of the selected articles.[5]

Eligibility criteria

The research question was framed employing the "PICOS" framework. The research question formulated fitted the eligibility criteria.

Population – Smokers with implant placement.

Intervention – Follow-up for a certain period.

Comparison – Nonsmokers who had implant placement.

Outcome – The primary outcome assessed was the survival rate of implants in the oral cavity. A Secondary outcome such as marginal bone loss and soft-tissue involvement was considered wherever found.

Setting – Private practice or hospital settings.

Inclusion criteria

Any study employing cross-sectional, retrospective, or prospective study design with participants placed with osseointegrated dental implants in either of the jaws with subsequent follow-up and articles published in the English language only were included.

Exclusion criteria

Editorials, case reports, commentaries, animal studies, and articles written in a language other than English were excluded. Trials not having a comparison group were also not included.

Information sources

Search engines such as PubMed, Ovid, Embase, Scopus, and Journal on web databases were employed for literature search. Those of the relevant articles were identified, extracted in full through electronic and manual searches.

Search strategy

Keywords

Key terms used for the search included "Smoking tobacco;" "cigarette smoking;" "osseointegrated implants;" "implant-supported dental prosthesis;" "oral implants;" "endosseous implants;" "oral implants;" "periimplantitis;" "survival rate;" "marginal bone loss."

Boolean operators

The Boolean operator "OR" was used to complement truncated synonyms in each search attempt. The Boolean operator "AND" made up the sum of each four main search themes to specifically output papers to produce at least one result for each time.

Search limits

Searches incorporated literature until 2020 as the concluding year. Only sources in English were used.

Process of study identification

Endnote X8 was used to import the results of the search data and to remove the duplicates. The screening of abstracts was carried out by the use of the eligibility criteria and for those not excluded, full-text articles were searched for. These were then assessed for inclusion and upon acceptance, underwent data extraction and quality assessment. Articles failing to meet inclusion criteria were excluded.

Data collection

All the titles and the extracts were independently screened by the reviewers and upon a meticulous review of the full-text articles, the data were extracted and documented in a data extraction table, which shows depicting data items evaluated for the review.

Data items

The data extraction table will include Study ID, sample size, follow-up period, implant type, outcome, criteria employed, and study design.

Risk of bias in individual studies

Cochrane Handbook for Systemic Review of Interventions was used for assessing the quality of recruited studies.[6]

Criteria assessed were random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), and selective reporting (reporting bias).

Data synthesis

The total number of success and failures of implants in each study in both smoking and nonsmoking groups was obtained. When present, marginal bone loss was recorded as mean and standard deviation. The heterogeneity level of all studies was evaluated using heterogeneity Cochrane's test and I squared test to determine the percentage of variation because of heterogeneity. A random-effect model was used. Funnel plots were constructed to examine publication bias and for checking symmetry of effect size versus sample size.

Statistical analysis

Data analysis was carried out using RevMan 5.4 software, Cochrane Collaboration, London, United Kingdom.

RESULTS

The search strategy results in a total of 437 articles, of which 101 had to be excluded because of duplication. Further 259 articles had to be excluded as only abstracts were obtained of these articles. A total of 9 articles were included for the systematic review and the same were analyzed for meta-analysis [Figure 1]. The characteristics of the study are enlisted in Table 1. Two reviewers performed the data extraction and bias judgment. Any nonagreement between the reviewers was sorted out by seeking expert advice.

Of the 9 studies reviewed, 5 were of retrospective study design, and the rest employed prospective study. The majority of the studies evaluated Branemark implants. Follow-up time ranged from 5 years to the time of implant failure. Low risk of bias was seen in all the included studies [Table 2].

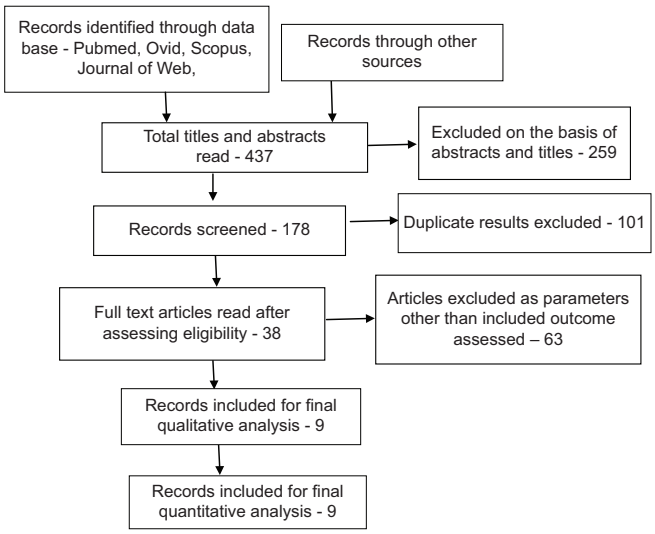

Figure 1: Flow chart diagram for article inclusion

A total of 3090 implants in smokers were assessed while 8994 in nonsmokers were followed up to evaluate for failure. Meta-analytic results showed that implant success rate was better in nonsmokers than smokers (odds ratio = 0.43, 95% confidence interval = 0.26–0.72, $P < 0.0001$), the random-effects model was adopted [Figure 2]. Funnel plots for both survival rate and marginal bone loss showed minimal publication bias [Figures 3-5].

There was no significant difference in marginal bone loss among smokers and nonsmokers [Figure 4].

DISCUSSION

A meta-analysis involving both retrospective and prospective study design was done to comparatively evaluate the survival rate and marginal bone loss among smokers and nonsmokers.

The survival rate amongst nonsmokers was significantly better than smokers at $P < 0.001$. This is in concordance with the reviews of Moraschini and Barboza[15] and Alfadda[16] The exact pathogenesis affecting this remains unclear. But probably osseointegration gets affected by the chemical constituents present in tobacco affecting the vascularity of surrounding implant tissues, which might result in poor bone loss. Roughly around 3 mg of nicotine and 20–30 ml of CO get inhaled with each cigarette smoke.[17] Nicotine seems to elevate plate aggregation and hamper fibroblastic function along with red blood cells, osteoblast, and macrophages.[18] Furthermore, CO has a greater affinity for hemoglobin competing with oxygen causing the formation of carboxyhemoglobin instead of oxyhemoglobin, which in turn reduces transportation of oxygen, causing hypoxia because of decreased oxygen tension in tissues.

Literature evidence also demonstrates that nicotine enhances pro-inflammatory cytokines expression thus playing an important part in accelerating alveolar bone loss around natural dentition. Increased ranges of pro-inflammatory cytokines are demonstrated in peri-implant sulcus fluid.

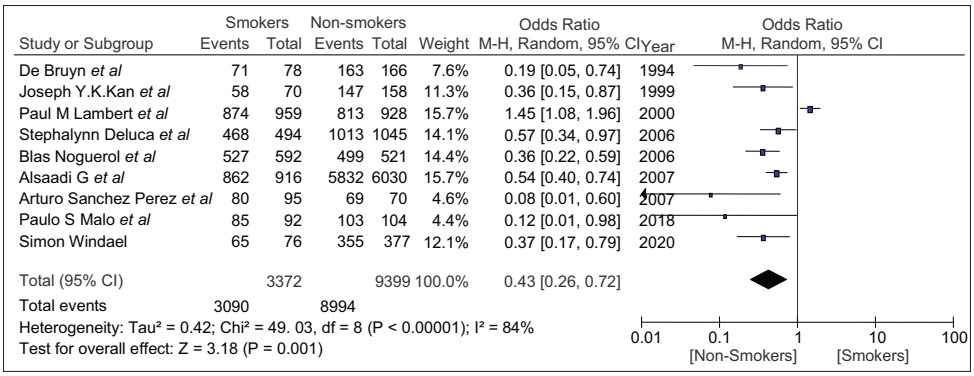

Figure 2: Forest plot showing implant success rate among smokers versus non smokers

Table 1: Characteristics of the studies included

Study ID	Sample	Follow up period	Implant type	Outcome	Criteria employed	Study design
Sánchez-Pérez *et al.*[7]	66 patients, 165 implants; 95 in smokers versus 70 in nonsmokers	5 years	Screw shaped, sand blasted and etched	Overall 16 implants failed, with 9.7% Survival rate - Smokers versus nonsmokers=84.2% versus 98.6%	Albrektsson's criteria	Retrospective analysis
De Bruyn and Collaert 1994[8]	208 patients, with 462 implants only in mandible	Not mentioned	Branemark fixtures	7 out of 78 and 3 out of 66 failed in nonsmokers	Mobility of tooth	Retrospective
Deluca *et al.*, 2006[9]	464 patients, 1852 implants; 1106 in females and 746 in males	Till the time of implant failure or the last follow up	Branemark endosseous (Nobel Biocare)	Overall implant failure was 7.72%. Smokers versus non-smokers was 23.08% versus 13.33%	Not mentioned	Prospective
Maló *et al.* 2018[10]	200 patients, 100 smokers, 100 nonsmokers	5 years	All on 4 concept - Nobel Biocare	Smokers exhibited an odds of 3.02 times (1.08-8.47) in having implant failure as compared to nonsmokers	Maintained function by retaining support reconstruction, absence of persistent infection and absence of radiolucent areas	Prospective study
Windael *et al.* 2020[11]	453 implants, 121 patients	10 years cumulative analysis Mean follow up=11.38 years	Implant with fluoride modified surface	Implant loss was higher in maxilla accounting to 5.4 times higher in smokers than in nonsmokers (P=0.003)	implant mobility, loss of integration, ongoing bone Loss, infection, persistent pain, or patient discomfort	Prospective study
Noguerol *et al,* 2006[12]	1084 implants, 316 implants	10 year follow up	Brane mark implants (nonthreaded type)	Smoking had an odds of 2.5 times (95% CI - 1.3-4.79) having an implant failure as compared to nonsmokers	Mobility, pain, gingival inflammation	Retrospective
Kan al. 1999[13]	60 patients placed with 84 grafted maxillary sinuses. 228 endosseous implants	Not given	Branemark root implants	Over all 76% survival rate was seen, with no difference between smokers and nonsmokers	Smith and Zarb criteria	Retrospective
Alsaadi *et al.*, 2017[14]	2004 patients; 1212 females and 792 males 6946 implants of Branemark type	Not given	Screw shaped Branemark system which were either machined or Ti-unite surface	Smoking along with osteoporosis and implant characteristics are associated with early implant failures	Lekholm and Zarb (1985) index	Retrospective study

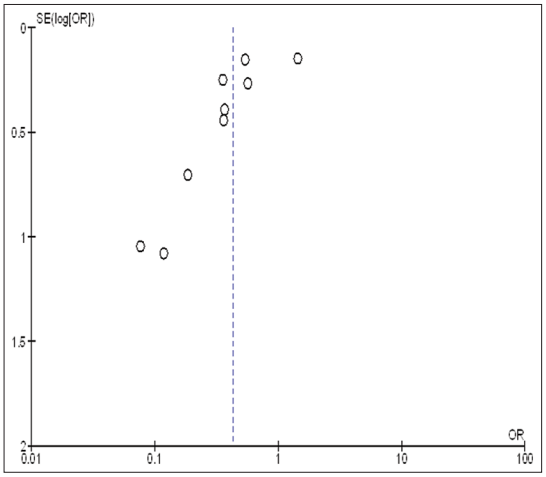

Figure 3: Funnel plot for survival rate among smokers versus non smokers

Nicotine has the potential in suppressing cellular healing response and increasing biofilm accumulation in smokers.[19,20]

No significant difference in the marginal bone loss was seen between smokers and nonsmokers. This was contradictory to the review of Alfadda[16] where a greater difference was noted between the groups. They justified it with amalgamating effects of tobacco chemicals on bone vascularity.

Publication bias in both the analysis was found to nonsignificant. The risk of bias assessed demonstrated an overall low risk highlighting the higher quality of the studies included.

The studies included in the present analysis employed cross-sectional, retrospective, or prospective study design, which is categorized under Level 2 under the evidence-based criteria assessment of Oxford Center for Evidence-Based Medicine.[21]

Though the choice of osseointegrated implants provides an excellent option for missing teeth replacement, certain other factors have to be considered such as plaque accumulation, peri-implant tissue inflammation, systemic-factors, and occlusal variables, which may influence osseointegration.[22,23] Furthermore, measuring nicotine levels to assess smoking status is recommended for further research to establish more credibility.

Table 2: Risk of bias in included studies

Study	Selection bias		Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)
	Random sequence generation	Allocation concealment				
Arturo Sanchez Perez *et al.*	+	U	++	++	+	+
DeBruyn *et al.*, 1994	U	++	+	+	+	+
Stephalyn Deluca *et al.*, 2006	+	+	+	+	+	+
Paulo Malo *et al.* 2018	+	U	++	+	+	+
Simon Windael *et al.* 2020	++	+	+	U	+	+
Blas Noguerol *et al.*, 2006	+	++	+	+	+	+
Joseph Y Kan *et al.* 1999	+	+	+	+	+	+
Alsaadi G *et al.*, 2017	+	+	+	+	+	+
Arturo Sanchez Perez *et al.*	+	++	U	+	+	+

U: Uncertain, +: Low risk, ++: Moderate risk

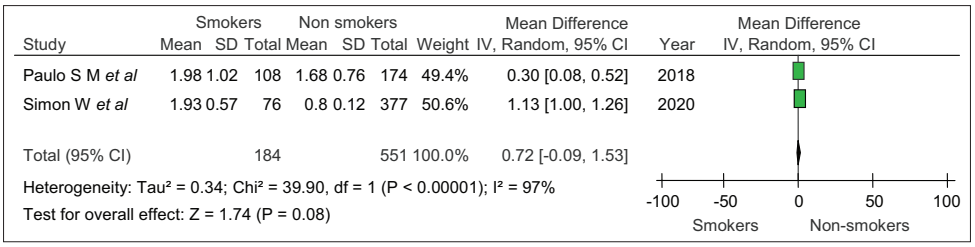

Figure 4: Forest plot showing marginal bone loss among smokers versus non smokers

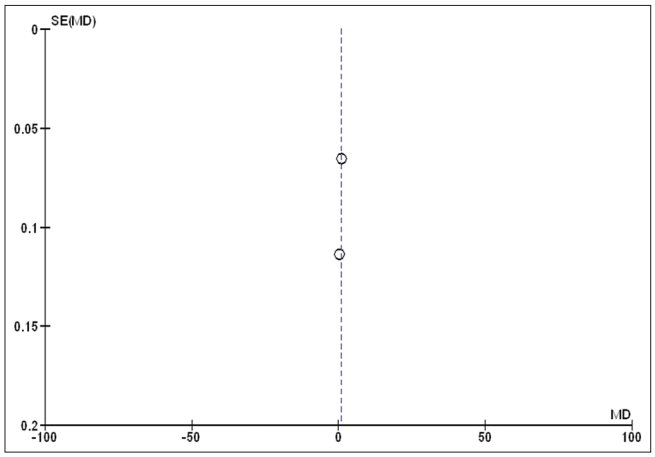

Figure 5: Funnel plot for marginal bone loss among smokers versus non smokers

However, the retrospective nature of the studies does carry some limitations. To better appreciate the influence of smoking in the success of osseointegrated implants, prospective, controlled, and randomized studies are needed which are evaluated using clinical and radiographic criteria. Furthermore, the fewer number of eligible studies could have an impact on the study weight.

CONCLUSION

Smoking proves to be detrimental to survival rate and marginal bone loss in osseointegrated implants. Education regarding the effect of smoking on peri-implant health must be given by the clinicians and reinforced at every phase.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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