

Smoking and Complications of Endosseous Dental Implants*

Devorah Schwartz-Arad, Naama Samet, Nachum Samet, and Avi Mamlider

Background: The purpose of this study was to compare the incidence of the complications and survival rate related to dental implants among smokers and non-smokers, and to evaluate the influence of smoking by analyzing data of 959 implants placed in 261 patients during the years 1995 to 1998.

Methods: Patients were divided into 3 groups: non-smokers, mild smokers (up to 10 cigarettes per day) and heavy smokers (more than 10 cigarettes per day); smokers were divided into 2 subgroups according to duration of smoking (less or more than 10 years). Complications included minor (spontaneous implant exposure), major (spontaneous implant exposure requiring surgical intervention), and implant failure. The influence of smoking was analyzed for the type of implant cover screw and immediate versus late implantation.

Results: The overall failure rate was 2% for non-smokers and 4% for all smokers. Minor and major complications were found in higher percentages (46%) in the smoking groups than in the non-smoking group (31%). A significantly higher incidence of complications was found among smokers who received dental implants with high cover screws (63%) compared to those who received dental implants with flat cover screws (27%).

Conclusions: This study establishes a relationship between implant complications and smoking, implant type (external or internal hex), and time of implantation as significant factors. A higher incidence of complications was found in the smoking group, especially in implants that had a high cover screw. Most complications will not lead to failures. Immediate implants failed less frequently than non-immediate implants. Limiting or reducing smoking habits will decrease complications of endosseous dental implants. *J Periodontol 2002;73:153-157.*

KEY WORDS

Dental implants, endosseous/complications; smoking/adverse effects; comparison studies.

Titanium endosseous implants have been increasingly used in various edentulous situations for well over a decade. Cigarette smoking has long been suspected as adversely affecting wound healing. Arteriolar vasoconstriction and decreased blood flow are seen in response to smoking.^{1,2}

In the oral cavity, an increase in plaque accumulation, a higher incidence of gingivitis and periodontitis, a higher rate of tooth loss, and an increased resorption of the alveolar ridge have been found among smokers. Bain and Moy² assessed the various factors that predispose implants to failure in a group of 540 patients who had received 2,194 Bråne-mark implants. Smoking was the most significant factor. De Bruyn and Collaert³ found that smokers demonstrated a significantly higher failure rate before functional loading of implants than non-smokers. Lindquist et al.^{4,5} compared marginal bone loss around osseointegrated dental implants among smokers and non-smokers. Among smokers who also had poor oral hygiene, marginal bone loss was nearly 3 times as great as that seen in non-smokers. It has also been suggested that smokers suffer detrimental effects around successfully integrated maxillary implants, with a significantly greater bleeding index, greater mean peri-implant probing depth, more frequent peri-implant inflammation, and radiographically greater mesial and distal bone loss.⁶

Implant failure is a result of a multifactorial process. Significant factors that influence prognosis include length and diameter of the implant,⁷ implant loca-

* Department of Oral and Maxillofacial Surgery, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.

tion,⁸ bone quality,⁹ and type of edentulous area treated.¹⁰

It is difficult to assess adverse effects of smoking on the prognosis of implants on the basis of implant failure alone. Specific factors such as the type of implant cover screw and immediate versus late implantation can also be assessed and comparisons made between smokers and non-smokers. These factors, related to clinical complications, enable the survival rate of implants to be evaluated.

The purpose of this study was to compare the incidence of the complications and survival rate related to dental implants among smokers and non-smokers, and to evaluate the influence of smoking by analyzing data of 959 implants placed in 261 patients during the years 1995 to 1998.

MATERIALS AND METHODS

The study was based on data from 261 patients (18 to 67 years, mean 48 years) who received 959 implants. Information included complete medical and dental history, thorough clinical and radiographic evaluation, and specific emphasis on smoking habits. There were 172 non-smokers with 579 implants and 89 smokers with 380 implants.

A single surgeon (DSA) inserted all implants between the years 1995 and 1998 under sterile conditions, following a protocol described by Schwartz-Arad et al.¹¹⁻¹⁴ Briefly, amoxicillin (1 g) and dexamethasone (8 mg) were administered 1 hour before surgery. For patients allergic to penicillin, erythromycin (0.5 g) was used. Either amoxicillin (1.5 g/day) or erythromycin (2 g/day) was continued for 5 to 7 days post-surgery, and dexamethasone (4 mg/day) was administered for 2 additional days.

Criteria for accepting patients into the study group were adequate information regarding age, gender, and health status; pre- and postoperative radiographs; and follow-up for at least 6 months postimplantation.

All smoking habits were known at the time of implantation. Smokers were divided into 2 subgroups according to the number of cigarettes per day (mild smokers, less than 10; heavy smokers, more than 10) and duration of smoking (mild smokers, less than 10 years; heavy smokers, more than 10 years).

A total of 386 implants had a high cover screw and 573 had a flat cover screw. Of the 959 implants, 288 were "immediate."

Smoking and non-smoking patients were divided into 2 groups: patients who demonstrated no complications between the 2 surgical stages and those with complications, i.e., spontaneous implant exposure without surgical intervention (minor), spontaneous implant exposure with surgical intervention (major), or complete implant failure during the surgical phase requiring implant removal.¹¹⁻¹⁴

The survival rate of each group was calculated. Two-way analysis of variance test was used to analyze implant type and smoking.

RESULTS

There was no significant difference in age, gender, and number of implants per patient or average implant length between smoking and non-smoking groups. Generally, there was a significantly higher incidence of complications ($P < 0.05$) in both smoking groups when the number of cigarettes per day was considered (Table 1). There was a significantly higher incidence ($P < 0.04$) of complications as the number of smoking years increased (Table 2).

The type of implant cover screw and immediate versus delayed implantation were assessed and compared between smokers and non-smokers. Only 22 (2%) implants were classified as failures, 33 (3%) had a major complication, 297 (31%) had a minor complication, and 607 (64%) had no complications.

In the present study, the number and percentage of failures were very low; therefore, all complications (minor, major, and failures) were grouped together.

Of the 959 implants inserted, 40% (386) had high cover screws and 60% (573) had flat cover screws (Table 3). A lower incidence of complications occurred in both groups when implants with flat cover screws were used. The complication rate doubled for smokers when using implants with high cover screws ($P < 0.014$).

Table 1.

Complication Rate According to Number of Cigarettes Smoked per Day

Group	N	N Implants	No Complications
Non-smokers	579	402 (69%)	177 (31%)
Smokers			
<10/day	127	74 (58%)	53 (42%)
>10/day	253	131 (52%)	122 (48%)

Implant complications for all smokers versus non-smokers, $P < 0.05$.

Table 2.

Complication Rate According to Duration of Smoking

Group	N	N Implants	No Complications
Non-smokers	579	402 (69%)	177 (31%)
Smokers			
<10 years	103	66 (64%)	37 (36%)
>10 years	277	139 (50%)	138 (50%)

Increased relationship between complications and years of smoking, $P < 0.04$.

Table 4 shows that 288 (30%) implants were immediate and 671 (70%) were inserted at least 3 months after extraction. There were more complications in the smoker group regardless of the time of implantation. A higher incidence of complications was found among smokers who received immediate implants ($P < 0.05$). Table 5 shows the characteristics of failed implants. Most of the failed implants in non-smokers occurred at a rate of 1 implant per person compared to smokers, where each person had 1 to 3 failed implants (12 for 7 individuals). The percentage of failed implants with high and flat cover screws was 64% and 36%, respectively; the percentage of failed immediate and non-immediate implants was 22% and 78%, respectively.

A significant statistical interaction was found between the 2 types of implant cover screws and smoking. Smoking had no effect on implants with flat cover screws; however, it did have an effect on the complication rate ($P < 0.014$) of implants with high cover screws. A statistically significant difference between the complication rate in the smoking and non-

Table 3.
Complication Rate According to Type of Cover Screw

Implant Type	Non-Smokers (n = 579)	Smokers (n = 380)
Flat cover screw		
No complications	242 (71%)	169 (73%)
Complications	100 (29%)	62 (27%)
Total	342	231
High cover screw		
No complications	160 (68%)	55 (37%)
Complications	77 (32%)	94 (63%)
Total	237	149

Table 4.
Complication Rate According to Immediate Versus Delayed Implants

Implant Type	Non-Smokers (n = 579)	Smokers (n = 380)
Immediate		
No complications	113 (66%)	62 (53%)
Complications	58 (34%)	55 (47%)
Total	171	117
Delayed		
No complications	289 (71%)	176 (67%)
Complications	119 (29%)	87 (33%)
Total	408	263

Table 5.
Characteristics of Failed Implants

Patient	Failed Implants	Cigarettes/Day	Type Cover Screw	Immediate (I)/Delayed (D)
1	1	0	H	D
2	1	0	H	D
3	1	0	H	D
4	1	0	H	D
5	1	0	H	D
6	1	0	H	D
7	1	0	F	I
8	1	0	F	I
9	2	0	F	D
10	1	40	H	D
11	2	40	H	D
12	2	25	H	D, I
13	3	20	H	D, D, I
14	1	25	F	D
15	1	20	F	D
16	2	30	F	D, I

H = high cover screw; F = flat cover screw.

smoking groups ($P < 0.05$) was found. No difference was found in age, gender, and number of implants for patients, or average implant length between the 2 groups.

DISCUSSION

Smoking has been shown to compromise healing after mucogingival surgery.^{7,8,15,16} Tobacco use has been associated with oral cancer, periodontal disease, leukoplakia, stomatitis nicotina, and impaired gingival bleeding.¹⁷⁻¹⁹ Gorman et al.²⁰ have demonstrated that smoking is a contributing factor to implant failure between time of implant placement and second-stage surgery. The failure rate was found to be twice that of non-smokers.²⁰

In the present study, the number and percentage of failures were very low; therefore, all complications were grouped together. Although it was classified as a complication in this study, spontaneous early exposure following implant insertion was accompanied by uneventful healing in most cases. The current study reports a higher incidence of premature spontaneous exposure in implants with high cover screws compared to

implants with flat cover screws (Table 3). Very little attention has been given to this phenomenon in implant research. Adell et al.²¹ reported that early perforations in the mucosa were observed in 4.6% of implants. According to Tal,²² 13.7% of implants were spontaneously exposed. The rate of exposure was higher in the external hex implants than in the internal hex implants.

Although spontaneous exposure of an implant was defined as a complication, it does not necessarily lead to a failure, as most of the failed implants in the present study had high cover screws (64%). Surprisingly, immediate implants had a much lower failure rate (22%) compared to delayed implants (78%) (Table 5).

The sample size for smokers was relatively small; however, it is clear that there is a significant benefit favoring non-smokers.²³ A lower complication rate has been found for non-smokers in whom implants with flat cover screws are used as opposed to smokers with a high cover screw.²⁴ Numerous studies have shown^{11,13,14,25,26} that immediate implantation has a high survival rate. Smokers in the present study who had immediate implantation with a high cover screw also had a significantly higher rate of complications compared to non-smokers with immediate implantation.

It is beyond the scope of this article to discuss the possible mechanisms by which smoking increases destructive implant complications. These have been detailed elsewhere.^{4,27-29} The present study does not provide any insight into the mechanism associated with failures in smokers; however, it is probable that these relate to any or all factors, such as systemic vasoconstriction, reduced blood flow, increased platelet aggregation, and polymorphonuclear leukocyte dysfunction, which have all been identified in smokers.³⁰⁻³⁴

CONCLUSIONS

Patients who smoke, as well as their dentists/surgeons, should anticipate more complications after implant placement requiring surgical intervention. Smokers have a higher incidence of complications, especially in implants with a high cover screw. However, most complications will not lead to failure. Immediate implants failed less frequently than delayed implants. While a relationship was established between implant complications and smoking, smoking duration, implant type (external or internal hex), and time of implantation as significant factors, it cannot be assumed that they are the only or most significant factors. Further research is necessary to identify other possible factors that contribute to failure. However, potential implant patients should be advised that smoking could have a harmful effect on dental implants. Limiting or

reducing smoking habits will decrease complications of endosseous dental implants.

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Send reprint requests to: Dr. Devorah Schwartz-Arad, Department of Oral and Maxillofacial Surgery, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel. Fax: 972-3-6409250; e-mail: dubish@post.tau.ac.il.

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