http://dx.doi.org/10.14368/jdras.2015.31.1.10
ISSN 2233-4084

Original Article

Factors affecting the survival of implants: a long-term retrospective study

Susanna Song, Jae-Kwan Lee, Heung-Sik Um, Beom-Seok Chang*
Department of Periodontology and Research Institute of Oral Sciences, Gangneung-Wonju National University College of Dentistry, Gangneung, Republic of Korea

Purpose: The aim of the present study was to evaluate the long-term survival of implants retrospectively and determine the risk factors associated with implant failure. **Materials and Methods:** Of all implants that were placed at the Department of Periodontology of the Dental Hospital of Gangneung-Wonju National University from January 1998 to December 2012, 2265 implants that were followed up until June 2013 were included in this study. Data were collected from clinical and radiographic examinations from previous visits. The information gathered included gender, age, smoking status, implant diameter, implant length, surface of implant, location of implant within the dental arch, surgical techniques and existence of complications. **Results:** The survival rate before loading was 98.9%. The cumulative survival rate after 5 years of loading was 97.2%, and after 15 years of loading was 95.2%. In a simple logistic regression analysis, gender (P = 0.016), smoking status (P = 0.001), location of implant (P = 0.020) and existence of complications (P = 0.002) were statistically associated with implant failure and included in the multiple regression analysis. As a result of multiple logistic regression analysis, the variables statistically associated with implant failure (P < 0.05) were smoking status (P = 0.049) and existence of complications (P < 0.001). **Conclusion:** The cumulative survival rate of dental implants after 15 years of loading was 95.2% and that the variables statistically associated with implant failure were smoking status and existence of complications. **(J Dent Rehabil Appl Sci 2015;31(1):10-9)**

Key words: dental implants; survival rate; retrospective study; risk factors

Introduction

Reconstruction of fully or partially edentulous areas with osseointegrated implants is one of the most reliable prosthetic treatments, with survival rates above 90% in long-term studies.[1,2] Despite these high survival rates, there are still complications and failures in implant treatment. Previous studies have reported early failures in 0.7% to 7.4% of cases and late failures in 2.1% to 11.3% of cases.[1] Therefore, the identification of risk factors associated with implant failure is essential for treatment planning.

Risk factors for adverse outcomes range from implant design to coexisting systemic disease.[3] In several studies, diabetes, steroid therapy, osteoporosis, chemotherapy, and head and neck irradiation have been considered to be contraindications for the placement of implants.[4] Conversely, in other studies, individual medical problems did not correlate with an increase in implant failures. Rather, implant success was affected by bone quantity and quality and by surgical techniques.[5] A variety of studies have reported that to-

*Correspondence to: Beom-Seok Chang
Professor, Department of Periodontology, Gangneung-Wonju National University College of Dentistry, 7 Jukheon-gil, Gangneung, 210-702, Republic of Korea
Tel: +82-33-640-3188, Fax: +82-33-640-3113, E-mail: dentist@gwnu.ac.kr
Received: December 17, 2014/Last Revision: March 3, 2015/Accepted: March 2, 2015

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bacco use has a negative effect on implant survival.[6,7] However, no obvious evidence has been presented concerning the influence of tobacco use on the survival rates of implants.[2,7] The effect of a history of periodontal disease on implant failure is also controversial. Several authors reported that there may be an increased risk for implant failure in periodontally compromised patients,[8,9] while other authors insisted that the presence of periodontal pathogens at peri-implant sites does not necessarily indicate future implant failure.[10,11]

Because the results obtained from numerous studies are contradictory, the questions raised by patients cannot be answered. In spite of the wide range of available studies, consistent conclusions cannot yet be drawn on the relationship between these factors and the long-term outcomes of implants. There is a clear need to obtain further scientific evidence in this area. Therefore, the aim of the present study was to evaluate the long-term survival of implants retrospectively and determine the risk factors associated with implant failure.

Materials and Methods

Data collection

A retrospective chart review was conducted for all implants that were placed at the Department of Periodontology of the Dental Hospital of Gangneung-Wonju National University from January 1998 to December 2012 (IRB 2013-13). Of all implants that were included the chart review, only implants that were followed up until June 2013 were included in this study. Data were collected from clinical and radiographic examinations from previous visits. The information gathered included the following:

- Gender
- Age (classified into three categories: < 50 years, 50 - 59 years and ≧ 60 years)
- Smoking status (people smoking 1 cigarette or more per day at the time of implant placement were categorized as a smokers)
- Implant diameter (classified into three categories: < 3.75 mm, 3.75 - 4.5 mm, ≧ 5 mm)
- Implant length (classified into two categories: < 10 mm, ≧ 10 mm, the classification criteria of 10 mm is based on the definition of a short implant[12])
- Surface of implant (classified into three categories: blasted, sand-blasted and acid etched, and anodized surface)
- Location of implant within the dental arch (classified into four categories: maxillary anterior, maxillary posterior, mandibular anterior and mandibular posterior regions)
- Surgical techniques (specific procedures that were performed to place the implants: guided bone regeneration, sinus elevation with a crestal approach and sinus elevation with a lateral approach)
- Complications (biological and mechanical complications: peri-implant mucositis, peri-implantitis, implant periapical lesion and fracture of fixture, screw or prosthesis)
- Dates of implant placement, prosthesis placement, implant removal and the last follow-up visit

An implant failure was defined as the removal of the implant for any reason.[13] Implants were regarded as surviving when they were present in the oral cavity at follow-up visits. Total survival time was defined as the period from the date of implant placement to the date of implant removal or the last follow-up visit.[13] Implant failure was classified as early failure if it occurred before functional loading, or late failure if it occurred after functional loading.[14]

Statistical analyses

After the data collection, statistical analyses were performed. The cumulative survival rates of implants were calculated by the life table method at annual intervals and a Kaplan-Meier survival curve was obtained. To determine the potential risk factors associated with implant failure, a simple logistic regression analysis was performed. Implant failure was the dependent variable and all independent variables were entered separately as categorical variables. Following the simple regression analysis, independent variables with $P < 0.1$ were selected and included in a multiple regression analysis to eliminate possible

confounding variables. A multiple logistic regression analysis was performed for implant failure as the dependent variable and independent variables with $P < 0.05$ were considered statistically associated with implant failure. In all types of analyses, each implant was regarded as the analysis unit. Thus multiple implants from the same patient had the same patient-related covariates. All analyses were conducted using statistical software (SPSS™ 20, IBM Inc., Chicago, IL, USA).

Results

During the period from January 1998 to December 2012, 5019 implants were placed in 1921 patients. Of these patients, 1146 were excluded from this study because of a lack of follow-up visits. Thus the study group was composed of 2265 implants from 775 patients.

Demographic characteristics

The study group consisted of 296 females and 479 males. The mean age at the last visit was 55.5 years (range: 19 to 81 years). Of 2265 implants, 854 implants (37.7%) were placed in females, and 1411 implants (62.3%) were placed in males. Six hundred thirty-four implants (28.0%) were placed in smokers, and 1631 implants (72.0%) were placed in non-smokers (Table 1).

Implant characteristics

The majority of the implants were of a diameter ≧ 3.75 mm (95.3%), and 4.7% were of a diameter < 3.75 mm. Most of the implants were ≧ 10 mm (95.8%) in length. The implants had a variety of surfaces including blasted (49.2%), anodized (30.7%), and SLA surfaces (20.1%) (Table 2).

Table 1. Distribution of implants according to demographic characteristics

		Placed implants (n = 2265)	Failed implants (n = 55)
		N (%)	N (%)
Gender	Female	854 (37.7)	12 (1.4)
	Male	1411 (62.3)	43 (3.0)
Age (yr)	< 50	413 (18.2)	13 (3.1)
	50 - 59	1083 (47.8)	25 (2.3)
	≥ 60	769 (34.0)	17 (2.2)
Smoking	No	1631 (72.0)	28 (1.7)
	Yes	634 (28.0)	27 (4.3)

Table 2. Distribution of implants according to implant characteristics

		Placed implants (n = 2265)	Failed implants (n = 55)
		N (%)	N (%)
Diameter (mm)	< 3.75	106 (4.7)	4 (3.8)
	3.75 - 4.5	1547 (68.3)	39 (2.5)
	≥ 5	612 (27.0)	12 (2.0)
Length (mm)	≥ 10	2170 (95.8)	51 (2.4)
	< 10	95 (4.2)	4 (4.2)
Surface	Blasted	1115 (49.2)	22 (2.0)
	Anodized	696 (30.7)	19 (2.7)
	SLA	454 (20.1)	14 (3.1)

Surgical characteristics and the existence of complications

One thousand one hundred and twenty-five implants were inserted in the maxilla (195 in the anterior and 930 in the posterior) and 1140 in the mandible (75 in the anterior and 1065 in the posterior). The guided bone regeneration (GBR) technique was used in 559 implants, and 368 implants were placed after maxillary sinus elevation (198 with the crestal approach and 170 with the lateral approach). The others (1338 implants) were placed without any specific procedure. Postoperative complications including peri-implant mucositis, peri-implantitis, implant periapical lesions and fractures of the fixture, screw or prosthesis occurred in 354 implants (15.6%) (Table 3).

Implant survival

Of the 2265 inserted implants, 55 (2.4%) failed. Twenty-five implants (1.1%) failed before loading (early) and 30 (1.3%) failed after loading (late). According to the Kaplan-Meier lifetime analysis (Table 4, Fig. 1), the cumulative survival rate after 5 years of loading was 97.2%, and after 15 years of loading was 95.2%.

Table 4. Cumulative survival rate of inserted implants

Time (yr)	No. of implants at beginning of interval	No. of failed implants during interval	Cumulative survival rate (%)
Place / Load	2265	25	98.9
Load / 1	2082	4	98.7
1 to 2	1699	8	98.2
2 to 3	1398	8	97.6
3 to 4	1093	2	97.4
4 to 5	834	2	97.2
5 to 6	651	1	97.0
6 to 7	478	0	97.0
7 to 8	326	2	96.4
8 to 9	253	3	95.2
9 to 10	141	0	95.2
10 to 11	43	0	95.2
11 to 12	13	0	95.2
12 to 13	2	0	95.2
13 to 14	2	0	95.2
14 to 15	2	0	95.2

Place / Load: placement of implant to time of loading.
Load / 1: time of loading to 1 year.

Table 3. Distribution of the implants according to surgical characteristics and the existence of complications

		Placed implants (n = 2265) N (%)	Failed implants (n = 55) N (%)
Location	Maxillary anterior	195 (8.6)	3 (1.5)
	Maxillary posterior	930 (41.1)	33 (3.5)
	Mandibular anterior	75 (3.3)	2 (2.7)
	Mandibular posterior	1065 (47.0)	17 (1.6)
Surgical technique	GBR	559 (24.7)	14 (2.5)
	Sinus elevation (Crestal)	198 (8.7)	7 (3.5)
	Sinus elevation (Lateral)	170 (7.5)	4 (2.4)
	Conventional	1338 (59.1)	30 (2.2)
Complications	Absence	1911 (84.4)	35 (1.8)
	Presence	354 (15.6)	20 (5.6)

GBR, guided bone regeneration.

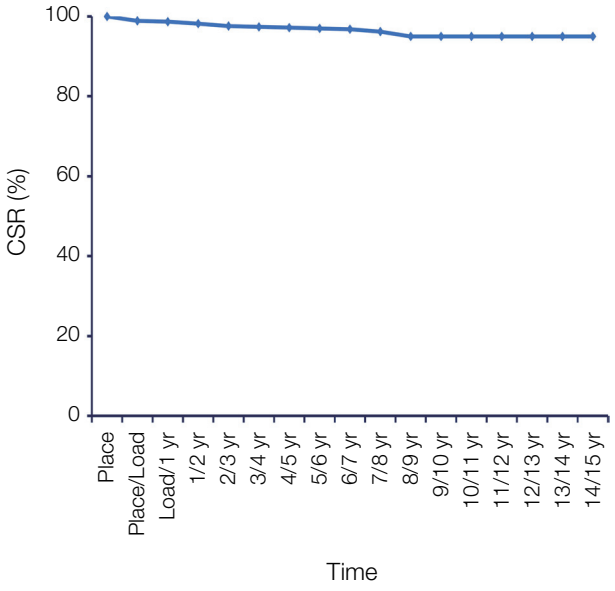


Fig. 1. Kaplan-Meier survival curve. CSR, cumulative survival rate.

Risk factors associated with implant failure

All independent variables including gender, age, smoking status, implant diameter, implant length, surface of implant, location of implant, surgical technique and existence of complications were entered into a simple logistic regression analysis (Table 5 - 7). Among these variables, gender ($P = 0.016$), smoking status ($P = 0.001$), location of implant ($P = 0.020$) and existence of complications ($P = 0.002$) were statistically associated with implant failure and included in the multiple regression analysis.

As a result of multiple logistic regression analysis (Table 8), the variables statistically associated with implant failure ($P < 0.05$) were smoking status ($P = 0.049$) and existence of complications ($P < 0.001$).

Table 5. Simple logistic regression analysis for risk factors associated with implant failure (Demographic variables)

		Odds ratio	95% Confidence Interval	*P* value
Gender				0.016*
	Female (baseline)			
	Male	2.206	1.156 to 4.206	0.016
Age (yr)				0.526
	< 50 (baseline)			
	50 - 59	0.757	0.385 to 1.487	0.419
	≥ 60	0.654	0.311 to 1.373	0.262
Smoking				0.001*
	No (baseline)			
	Yes	2.547	1.489 to 4.356	0.001

*Significant association ($P < 0.1$).

Table 6. Simple logistic regression analysis for risk factors associated with implant failure (Implant variables)

		Odds ratio	95% Confidence Interval	*P* value
Diameter (mm)				0.495
	< 3.75 (baseline)			
	3.75 - 4.5	0.659	0.231 to 1.881	0.436
	≥ 5	0.510	0.161 to 1.612	0.252
Length (mm)				0.256
	≥ 10 (baseline)			
	< 10	1.826	0.646 to 5.162	0.256
Surface				0.361
	Blasted (baseline)			
	Anodized	1.394	0.749 to 2.595	0.294
	SLA	1.581	0.802 to 3.118	0.186

Table 7. Simple logistic regression analysis for risk factors associated with implant failure (surgical variables and complications)

	Odds ratio	95% Confidence interval	*P* value
Location			0.020*
Maxillary anterior (baseline)			
Maxillary posterior	2.429	0.738 to 7.988	0.144
Mandibular anterior	1.753	0.287 to 10.708	0.543
Mandibular posterior	0.976	0.282 to 3.382	0.970
Surgical technique			0.672
GBR (baseline)			
Sinus elevation (Crestal)	1.329	0.534 to 3.309	0.541
Sinus elevation (Lateral)	0.874	0.286 to 2.669	0.813
Conventional	0.803	0.427 to 1.511	0.497
Complications			0.002*
Absence (baseline)			
Presence	2.486	1.387 to 4.457	0.002

GBR, guided bone regeneration.

Table 8. Multiple logistic regression analysis for risk factors associated with implant failure

Variables	Odds ratio	95% Confidence interval	*P* value
Gender			0.272
Female (baseline)			
Male	1.501	0.727 to 3.098	0.272
Smoking			0.049*
No (baseline)			
Yes	1.839	1.002 to 3.377	0.049
Location			0.085
Maxillary anterior (baseline)			
Maxillary posterior	2.395	0.722 to 7.943	0.153
Mandibular anterior	1.895	0.306 to 11.726	0.492
Mandibular posterior	1.166	0.336 to 4.055	0.809
Complications			< 0.001*
Absence (baseline)			
Presence	2.977	1.685 to 5.258	< 0.001

*Significant association ($P < 0.05$).

The implants placed in smokers were 1.839 times more likely to fail than the implants placed in non-smokers. The implants with complications were also at a greater risk of failure compared to the implants without complications, with an odds ratio of 2.977 : 1.

Discussion

The purpose of this retrospective study was to analyze the long-term outcomes of 2265 implants and determine the risk factors associated with implant failure. A retrospective chart review of implants placed at the department of periodontology of the dental hospital of Gangneung-Wonju national university from January 1998 to December 2012 was performed.

In the present study, the cumulative survival rate up to 15 years was 95.2%. Previously, Simonis et al.[15] reported a long-term cumulative survival rate of 82.94% up to 16 years. Additionally, Roos-Jansåker

et al.[2] assessed the long-term outcome of implant therapy and reported that the overall survival rate up to 14 years was 95.7%. Thus, the outcome of the present study is consistent with previous studies.

In this study, only 55 implants were removed. Some of these were concentrated in a small number of individuals. Fifty-five implant removals occurred in 47 patients and 15 of 55 removed implants were in 7 patients. Among them, five were smokers and two were non-smokers. Peri-implantitis occurred in 2 patients and implant periapical lesion occurred in 1 patient.

To identify the risk factors associated with implant failure, statistical analyses were performed. Using multiple logistic regression analysis, a significant relationship was found between implant failure and independent variables including smoking status and existence of complications. Smoking status has previously been regarded as a risk factor for implant failure. Bain and Moy[16] reported a failure rate of 11.3% in smokers and 4.76% in non-smokers. In more recent study, Huynh-Ba et al.[17] studied 273 implants placed in the posterior maxilla and reported that smoking markedly increased the risk for implant failure. In terms of existence of complications, Simonis et al.[15] referred to peri-implantitis as a complication with a very high risk of implant loss; of 21 cases, only 5 implants were functional after 16 years despite comprehensive treatments including implant debridement and administration of systemic antibiotics.

Some variables that were not significantly related to implant failure in multiple regression analysis but reached statistical significance in simple regression analysis included gender and location of implant. Males (odds ratio = 1.501) and maxillary posterior implants (odds ratio = 2.395) were associated with implant failure. These variables were previously identified as risk factors for implant failure. Zupnik et al.[18] reported that gender was the parameter with the strongest correlation with implant failure in a meta-analysis that demonstrated that males had a higher prevalence of destructive periodontal disease.[19] Because periodontal disease is widely recognized as a risk factor for peri-implantitis and implant failure,[20,21] the higher prevalence of periodontal disease in males may explain the outcome of the study. Anitua et al.[22] reported significantly lower survival for implants placed in the maxilla compared to the mandible. This difference might be the outcome of the less favorable osseous situation in patients requiring maxillary reconstruction. In addition, Moy et al.[3] studied 4680 implants in 1140 patients and reported that implants placed in the maxilla failed at almost twice rate of those placed in the mandible.

The present study had some limitations. First, an inherent limitation of retrospective studies is a risk for bias because only the implants that were followed up were included in the study group. The dropout rate (1146 of 1921 patients, 59.7%) could be considered high and must be considered when interpreting the results. Previous studies have suggested this as a reason for incomplete results.[17,23] Second, because the number of failed implants was very low (55 of 2265 implants, 2.4%), definitive conclusions could not be drawn. Alsaadi et al.[24] reported that due to the low number of implant failures, only potentially influential factors could be identified. Finally, numerous variables that are known to be significantly associated with implant failure were not included in our analyses. For example, diabetes has been significantly correlated with implant failure.[18] Rodrigo et al.[25] reported that resonance frequency analysis (RFA) values at restoration placement could significantly predict the outcomes of implants. Quirynen et al.[26] reported that a large proportion of failing implants may be explained by the lack of proper supportive periodontal therapy (SPT), and Ong et al.[27] proposed that the irregularity of SPT might influence the outcomes and differences between studies. Therefore, well-designed, controlled prospective studies that consider the above limitations are required.

Conclusion

We conclude that the cumulative survival rate of dental implants after 15 years of loading was 95.2% and that the variables statistically associated with implant failure were smoking status and existence of complications.

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임플란트의 생존에 영향을 미치는 요인에 대한 장기간의 후향적 연구

송수산나, 이재관, 엄흥식, 장범석*
강릉원주대학교 치과대학 치주과학교실

목적: 이 연구는 임플란트의 장기간 생존율을 후향적으로 평가하고, 이에 영향을 미치는 요인을 분석하는 것이었다.
연구 재료 및 방법: 1998년 1월부터 2012년 12월까지 강릉원주대학교 치과병원 치주과에서 식립된 임플란트 중 2013년 6월까지 주기적으로 검사가 이루어지고 있는 2265개의 임플란트를 대상으로 하였다. 환자의 진료기록부와 방사선 사진을 통해 성별, 연령, 흡연 여부, 임플란트 직경, 임플란트 길이, 임플란트 표면, 임플란트 식립 부위, 동반된 술식, 합병증 유무에 대한 자료를 조사하였다.
결과: 임플란트 식립 후 보철 전 생존율은 98.9%, 보철 후 5년간 누적생존율은 97.2%, 15년간 누적생존율은 95.2% 이었다. 단순로지스틱회귀분석 시 성별, 흡연 여부, 임플란트 식립 부위 및 합병증 유무가 임플란트 실패와 유의하게 관련되었다. 이 변수들로 다중로지스틱회귀분석을 시행한 결과, 흡연 여부와 합병증 유무만이 임플란트 실패와 유의하게 관련된 것으로 나타났다.
결론: 2265개의 임플란트를 대상으로 15년간의 누적생존율을 조사한 결과 95.2% 이었다. 흡연가이거나, 임플란트 합병증이 존재할 경우 임플란트의 실패율이 유의하게 증가되었다.

(구강회복응용과학지 2015;31(1):10-9)

주요어: 치과용 임플란트; 생존율; 후향적 연구; 위험 요인

*교신저자: 장범석
(210-702) 강원도 강릉시 죽헌길 7 강릉원주대학교 치과대학 치주과학교실
Tel: 033-640-3188 | Fax: 033-640-3113 | E-mail: dentist@gwnu.ac.kr
접수일: 2014년 12월 17일 | 수정일: 2015년 3월 3일 | 채택일: 2015년 3월 2일