Journal of Dental Sciences 19 (2024) 1741–1747

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jds.com

Original Article

Survival rate of implants performed at sites of previously failed implants and factors associated with failure: A retrospective investigation

Georgios S. Chatzopoulos [a,b*], Larry F. Wolff [a]

[a] Department of Developmental and Surgical Sciences, Division of Periodontology, School of Dentistry, University of Minnesota, Minneapolis, MN, USA
[b] Department of Preventive Dentistry, Periodontology and Implant Biology, School of Dentistry, Aristotle University of Thessaloniki, Thessaloniki, Greece

Received 28 September 2023; Final revision received 10 October 2023
Available online 22 October 2023

KEYWORDS
Dental implants;
Implant failure;
Reimplantation;
Risk factors;
Survival rate

Abstract *Background/purpose:* Although reimplantation is currently a common treatment procedure, little information on reimplantation success or failure is available in the literature. The purpose of the present investigation was to evaluate the survival rate of dental implants that were performed in sites of previously failed implants and identify factors associated with the treatment outcome.
Materials and methods: This retrospective study is based on a cohort of patients rehabilitated with dental implants in the dental clinics of the universities contributing data to the BigMouth network between 2011 and 2022. Implants replacing a previously failed implant at the same site were included. Cases of first and second reimplantations were included Information regarding patients' characteristics including age, gender, ethnicity, race, tobacco use, and systemic medical conditions were extracted from patients' files.
Results: Records of 50,333 dental implants placed in 20,842 patients over a 12-year period were screened. Three hundred seventy implants placed in 284 patients were replaced by another implant at the same site. The cumulative survival rates of implants inserted for the first time was 98.6 %, for the first replacements was 96.1 % and for the second replacements was 91.7 %. First reimplants exhibited a significantly higher risk of failure than initial implantation ($P < 0.001$). Similarly, second reimplants demonstrated significantly greater risk of failure ($P = 0.05$) when compared to initial implants. No significant associations were detected between replaced implant failures with any of the patient related parameters evaluated ($P > 0.05$).

* Corresponding author. University of Minnesota, School of Dentistry, Department of Developmental and Surgical Sciences, Division of Periodontology, 515 Delaware Street SE, Minneapolis, MN, 55455, USA.
E-mail address: chatz005@umn.edu (G.S. Chatzopoulos).

https://doi.org/10.1016/j.jds.2023.10.012

Conclusion: Within the limitations of the present study, dental implants replacing failed implants exhibited lower survival rates than the rates reported for the previous attempts of implant placement. No risk indicators for implant failure were identified. Additional factors should be examined in future studies.

Introduction

Dental implants in partially and completely edentulous patients are considered a great treatment option to replace missing teeth and they demonstrate high success rates of 97 % during the initial ten years and 75 % over 20 years.[1,2] Biological and technical complications may occur which can lead to implant failure.[3] Early implant failure is associated with lack of intimate bone to implant contact (lack of osseointegration) and occurs prior to or at abutment connection.[4] In contrast, late implant loss is observed after implant loading and it is mainly a result of peri-implantitis.[5] A number of systematic reviews have evaluated the effect of factors including smoking, systemic diseases as well as a history of periodontitis.[6,7] Technical complications are primarily associated with bruxism, heavy occlusal load, and the type of cantilever used in the prosthesis.[8]

Following an implant failure, a new treatment plan should be developed. For most cases with implant failure, reimplantation is the only fixed prosthetic solution.[9] Alternative options include a fixed partial denture, an implant tooth supported removable partial denture, a removable denture or preservation of the edentulous space without any replacement.[10] Implant replacement is considered a challenging situation due to the reduced vertical and horizontal bone dimensions as well as the decreased bone quality which is more pronounced in case of late implant loss.[11–13]

Reimplantation requires additional procedures, extra treatment costs and time. Therefore, it is crucial for the clinicians and patients to have information about the predictability of implant replacement.[14] Although a number of studies have been performed to evaluate the survival rates of implants placed at sites with history of implant failure, the small sample sizes limits the generalizability of their findings.[12–23] Although reimplantation is currently a common treatment procedure, little information on reimplantation success or failure is available in the literature. Using large datasets may provide an increased number of cases for analysis and therefore lead to strong conclusions. The purpose of the present investigation was to evaluate the survival rate of dental implants that were performed in sites of previously failed implants and identify patient-related factors associated with the treatment outcome using BigMouth Dental Data Repository. Following implant failure, severe bone and soft tissue deficiencies are observed and therefore we hypothesized that the survival rates of implants that replaced a previously failed implant will exhibit lower survival rates.

Materials and methods

Study design

This retrospective analysis of a cohort of patients received dental implant treatment in the university dental clinics of the institutions contributing to the BigMouth network. These institutions included Harvard University; University of Texas Health; The University of California, San Francisco; University of Colorado; Loma Linda University; University of Buffalo; The University of Iowa; The University of Minnesota; Tufts University of data collected between 2011 and 2022. The Institutional Review Board (IRB) of the University of Minnesota reviewed the study protocol and ethical review and approval were waived for this study (#STUDY00016865, 10/10/2022). It was further reviewed and approved by the BigMouth Consortium for Oral Health Research and Informatics clinical review committee. This study was conducted in agreement with the Helsinki Declaration of 1975 as most recently revised in 2013.

Study population

Records of patients who received dental implant treatment at any of the university dental schools contributing to the BigMouth network between 2011 and 2022 were evaluated. Dental Procedure Codes and Current Procedural Terminology procedures were utilized to identify implant patients. Initially, patients with at least one completed treatment code D0150 (comprehensive Oral Evaluation), D0120 (periodic oral evaluation provided to an established patient) or D0180 (comprehensive restorative and periodontal exam) were screened. Partially or totally edentulous patients with at least one implant placed were identified using the CDT D6010 (Surgical placement of implant body: endosteal implant). Implant failure was identified using the appropriate CDT D6100 (dental procedure for implant removal).

Inclusion and exclusion criteria

All patients with at least one failed implant were identified. Implants considered eligible for inclusion in the present study were based on the following criteria.

1. Implants were removed due to lack of osseointegration or significant bone loss, peri-implantitis or fracture:

2. Initial implantation was considered when a dental implant was placed for the first time into an edentulous area with no history of implant failure.
3. Reimplantation was defined as implants replacing a previously failed implant at the same site for the first time.
4. Second reimplantation was considered when implants replaced for the second time a previously failed implant of the same site.
5. All patients have consented to the treatment after discussing the alternative treatment options as well as the risks and benefits associated with each treatment option with the treating clinician.

Exclusion criteria: Dental records missing any of the examined parameters were excluded from the study analysis.

Data collection

Information regarding patients' characteristics including age, gender, ethnicity, race, tobacco use, and systemic medical conditions were extracted from patients' files, entered into a new dataset and validated by data analysts. The following independent variables were examined: Age (at the time of implant placement, continuous variable); Ethnicity (Hispanic, non-Hispanic, other); sex/gender (female, male); race (White, Asian, African American, Hispanic or Latino, Some other race); Tobacco use (yes, no); Marijuana use (yes, no); Methamphetamine use (yes, no); Systemic medical conditions (yes, no): Cardiovascular disorders (hypertension); Endocrine disorders (diabetes mellitus, thyroid problems); Infectious disease (AIDS, HIV); Kidney disorders (dialysis, kidney disease); Muscle/bone/connective tissue disorders (arthritis, osteoporosis, lupus); Neurological disorders (depression, Parkinson's disease, seizure/epilepsy); and Respiratory disorders (Asthma, sleep apnea).

Statistical analysis

Gender, ethnicity, race, tobacco use, marijuana use, methamphetamine use, and systemic medical conditions were presented as counts and percentages. Chi-square tests were performed comparing these parameters between the groups. Differences between groups in regards to age were calculated using t-tests. Survival analysis was performed using the Kaplan-Meier analysis and the respective plots were created. Cox regression analysis was used to calculate the hazard ratios (HR) and their 95 % confidence intervals (CIs). All tests of significance were evaluated at the 0.05 error level with a statistical software program SPSS v.28.0 (IBM, Armonk, NY, USA).

Results

The survival rates with implant failures of the included patient and implant records are shown schematically in Fig. 1. Records of 50,333 dental implants placed in 20,842 patients over a 12-year period were screened. In this total population of 20,842 individuals, 568 of them experienced at least one implant failure resulting in a survival rate of 97.3 % at patient level. Seven hundred twenty-five implants failed from the total 50,333 records assessed leading to a survival rate of 98.6 % over a follow-up time of 83.86 ± 57.57 months (range: 0–367 months). The 568 patients who experienced implant loss had a total of 703 implants. Out of these patients, 284 received one or two re-implantations. Two hundred eighty patients received one re-implantation, while four had two implant replacements. The demographic characteristics of those who experienced dental implant failure once and twice are shown in Table 1. At the patient level, the survival rate of the 1st re-implantations was 95.7 % (12 experienced implant failure of the 1st replacements) and for the 2nd re-implantations implant survival rate was 75 % (1 patient experienced implant loss of the 2nd replacement) which was significantly different ($P = 0.049$). The univariate analysis on the associations between patient factors and treatment outcome in the 1st re-implantation group is shown in Table 2. None of the examined patient factors were significantly associated with the treatment outcome of the 1st replacements ($P > 0.05$). Due to the small number of 2nd re-implantations (n = 4), no statistical analysis was performed to evaluate the effect of patient related factors to implant treatment outcome.

Three hundred seventy implants placed in 284 patients were replaced by another implant at the same site. The survival rate of the 1st re-implantations was 96.1 % (14 failed implants of the 358 examined). Out of the 14 failed 1st re-implantations, 12 were replaced by a third dental implant (2nd re-implantation). The survival rate for the second replacements (2nd re-implantations) was 91.7 % (1 failed implant of the 12 included). The majority of the included 1st re-implantations were in the maxilla (53.6 %) and in the posterior region (66.8 %). In regards to the 2nd re-implantations, 66.7 % of them were in the mandible and there were equally distributed between anterior and posterior region (50 %). Neither the region, nor the jaw that an implant was placed, were significantly associated with treatment outcome ($P > 0.05$).

The Kaplan-Meier curves comparing the cumulative survival of original implants (n = 50,333), 1st replacements/re-implantations (n = 358) and 2nd replacements/re-implantations (n = 12) are shown in Fig. 2. The survival time for the first group of implants was 358.41 (95 % CI: 357.53–359.28) months, for the first replacements 266.97 (95 % CI: 255.63–278.30) months and for the second replacements 147.58 (95 % CI: 120.01–175.14) months. A statistically significant difference was found ($p < 0.001$) between the survival rates of implants placed for the first time and implants placed into sites of previous failure for the first (1st re-implantations) or second (2nd re-implantations) time. First re-implants exhibited a significantly higher risk of failure than initial implantation (HR: 3.052, 95 % CI: 1.798–5.180, $P < 0.001$). Similarly, second re-implants demonstrated significantly greater risk of failure (HR:7.100, 95 % CI: 1.000–50.481, $P = 0.05$) when compared to original implants. No significant differences were observed in regards to the survival rates between the 1st and 2nd re-implantations ($P = 0.415$).

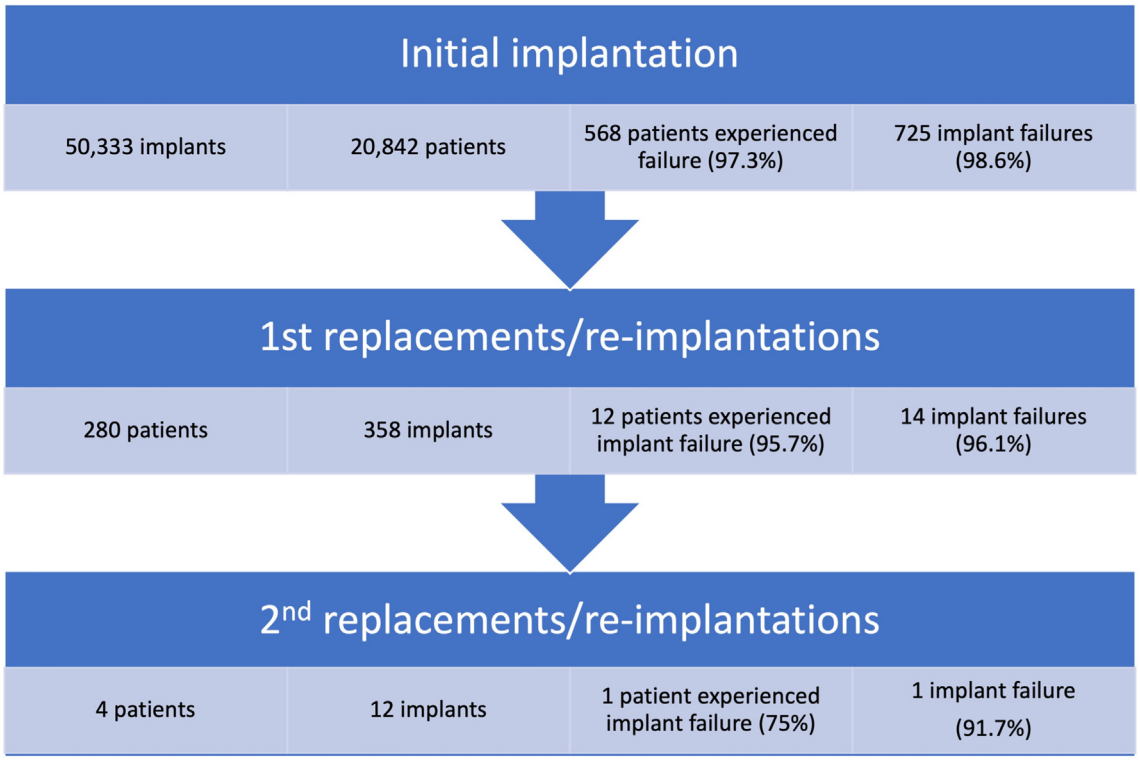

Figure 1 Survival rates with implant failures of the included patient and implant records.

Table 1 Demographic characteristics of the included population and separately for patients who experienced dental implant failure once and twice.

Patient-related characteristics		Total (N = 284)	1st re-implantation (n = 280)	2nd re-implantation (n = 4)
Age (mean (SD))		56.76 (13.11)	56.93 (13.09)	44.75 (8.99)
Gender (%)	Female	135 (47.5)	133 (47.5)	2 (50.0)
	Male	149 (52.5)	147 (52.5)	2 (50.0)
Ethnicity (%)	Non-Hispanic	267 (94.0)	263 (93.9)	4 (100.0)
	Hispanic	16 (5.6)	16 (5.7)	0 (0.0)
	Others	1 (0.4)	1 (0.4)	0 (0.0)
Race (%)	White	229 (80.6)	226 (80.7)	3 (75.0)
	Asian	14 (4.9)	14 (5.0)	0 (0.0)
	African American	W	20 (7.1)	1 (25.0)
	Hispanic or Latino	8 (2.8)	8 (2.9)	0 (0.0)
	Others	12 (4.2)	12 (4.3)	0 (0.)
Tobacco use (%)		21 (7.5)	21 (7.6)	0 (0.0)
Hypertension (%)		47 (16.5)	47 (16.8)	0 (0.0)
Marijuana use (%)		4 (1.4)	4 (1.4)	0 (0.0)
Diabetes (%)		14 (5.0)	14 (5.0)	0 (0.0)
Thyroid disorder (%)		17 (6.0)	17 (6.1)	0 (0.0)
HIV (%)		1 (0.4)	1 (0.4)	0 (0.0)
Kidney disease (%)		9 (3.2)	9 (3.2)	0 (0.0)
Arthritis (%)		31 (10.9)	31 (11.1)	0 (0.0)
Osteoporosis (%)		7 (2.5)	7 (2.5)	0 (0.0)
Depression (%)		21 (7.4)	21 (7.5)	0 (0.0)
Asthma (%)		11 (3.9)	11 (4.0)	0 (0.0)
Sleep apnea (%)		6 (2.1)	6 (2.2)	0 (0.0)
Treatment outcome	Survived	271 (95.4)	265 (95.7)	3 (75.0)
	Failed	13 (4.6)	12 (4.3)	1 (25.0)

Abbreviations: SD, standard deviation.

Table 2 Univariate analysis on the associations between patient factors and treatment outcome in the 1st re-implantation group.

Patient-related characteristics		Total (N = 280)	Patients with implant survival (n = 268)	Patients with implant failure (n = 12)	*P*-value[a]
Age (mean (SD))		56.93 (13.09)	56.95 (12.91)	56.42 (17.40)	0.89
Gender (%)	Female	133 (47.5)	127 (47.4)	6 (4.5)	0.86
	Male	147 (52.5)	141 (52.6)	6 (4.1)	
Ethnicity (%)	Non-Hispanic	263 (93.9)	252 (94.0)	11 (91.7)	0.90
	Hispanic	16 (5.7)	15 (5.6)	1 (8.3)	
	Others	1 (0.4)	1 (0.4)	0 (0.0)	
Race (%)	White	226 (80.7)	216 (80.6)	10 (83.3)	0.64
	Asian	14 (5.0)	14 (5.2)	0 (0.0)	
	African American	20 (7.1)	19 (7.1)	1 (8.3)	
	Hispanic or Latino	8 (2.9)	7 (2.6)	1 (8.3)	
	Others	12 (4.3)	12 (4.5)	0 (0.0)	
Tobacco use (%)		21 (7.6)	19 (7.2)	2 (16.7)	0.22
Hypertension (%)		47 (16.8)	44 (16.4)	3 (25.0)	0.44
Marijuana use (%)		4 (1.4)	4 (1.5)	0 (0.0)	0.67
Diabetes (%)		14 (5.0)	13 (4.9)	1 (8.3)	0.59
Thyroid disorder (%)		17 (6.1)	16 (6.0)	1 (8.3)	0.74
HIV (%)		1 (0.4)	1 (0.4)	0 (0.0)	0.83
Kidney disease (%)		9 (3.2)	9 (3.2)	0 (0.0)	0.52
Arthritis (%)		31 (11.1)	28 (10.4)	3 (25.0)	0.12
Osteoporosis (%)		7 (2.5)	7 (2.5)	0 (0.0)	0.57
Depression (%)		21 (7.5)	20 (7.5)	1 (8.3)	0.91
Asthma (%)		11 (4.0)	11 (4.1)	0 (0.0)	0.47
Sleep apnea (%)		6 (2.2)	6 (2.2)	0 (0.0)	0.60

Abbreviations: SD, standard deviation.
[a] Variables were compared between implant survival and failure groups using chi-square test. There were no significant associations between patient factors and treatment outcome in the 1st re-implantation group ($P > 0.05$).

Discussion

The present retrospective study aimed to evaluate the survival rates of dental implants that replaced previously failed implants at the same site and identify patient related factors associated with the treatment outcome using a large dental records database in the United States, the BigMouth Dental Data Repository. In the included cohort, 95.7 % of the patients maintained the first replaced implant (1st re-implantation) and in 75 % of the included population the 2nd re-implantations survived. At implant level, the survival rates of the 1st and 2nd replacements were found to be 96.1 % and 91.7 %, respectively, while the implant survival rate of the original group was 98.6 %. Both 1st and 2nd replacements exhibited significantly lower survival rates than the initial cohort, while no significant difference was detected between the 1st and 2nd re-implantations.

The survival rate of the 1st re-implantations (96.1 %) was higher compared to most of the previous studies. A meta-analysis of 11 studies that included 704 replaced implants placed in 579 patients reported a survival rate of 88.7 % for implants placed in previous failed sites.[24] Overall, the implant survival of 1st replacements ranged between 71 and 100 % after 7–180 months. These investigations included different numbers of patients ranging from ten[21] to 144,[9] while the number of replaced implants (1st replacements) were between 15[16] to 159.[15] The present investigation included 280 patients and 358 re-implantations as well as four patients with 12 implants in the 2nd replacements/re-implantations group. In regards to the number of 1st re-placements, the present study has almost double the number of implants analyzed when compared to previously published research.[15] Similar survival rate was found in a study by Wang et al. that included replacements of early failed implants and demonstrated a survival rate of 94.6 %.[12]

The majority of the previous studies has reported implant treatment outcome at sites with a history of one implant failure. Only five studies analyzed the survival of implants placed for the third time at a specific site.[9,14,15,17,18] The number of replaced implants ranged between 2[14] to 15[19] in 2[14] to 12[19] patients. The weighted survival rate of the 2nd replacements based on the meta-analysis[24] was 67.1 % and rates ranged between 50 %[14] and 100 %.[18] In the present investigation, 12 implants placed as third attempts (2nd re-implantation) in 4 patients were included in the analysis. One implant failed leading to an implant survival rate of 91.7 %. This outcome is better than in the majority of the previous studies. Four out of the five previous research investigations reported survival rates lower than 85 %.[9,14,15,17]

The survival time for the first group of implants (initial implantation) was 363.95 months, for the first re-placements 267.01 months and for the second re-placements 147.58 months. Implants placed for the first time showed significantly higher survival rates than 1st re-placements and 2nd replacements. In the present study, 1st

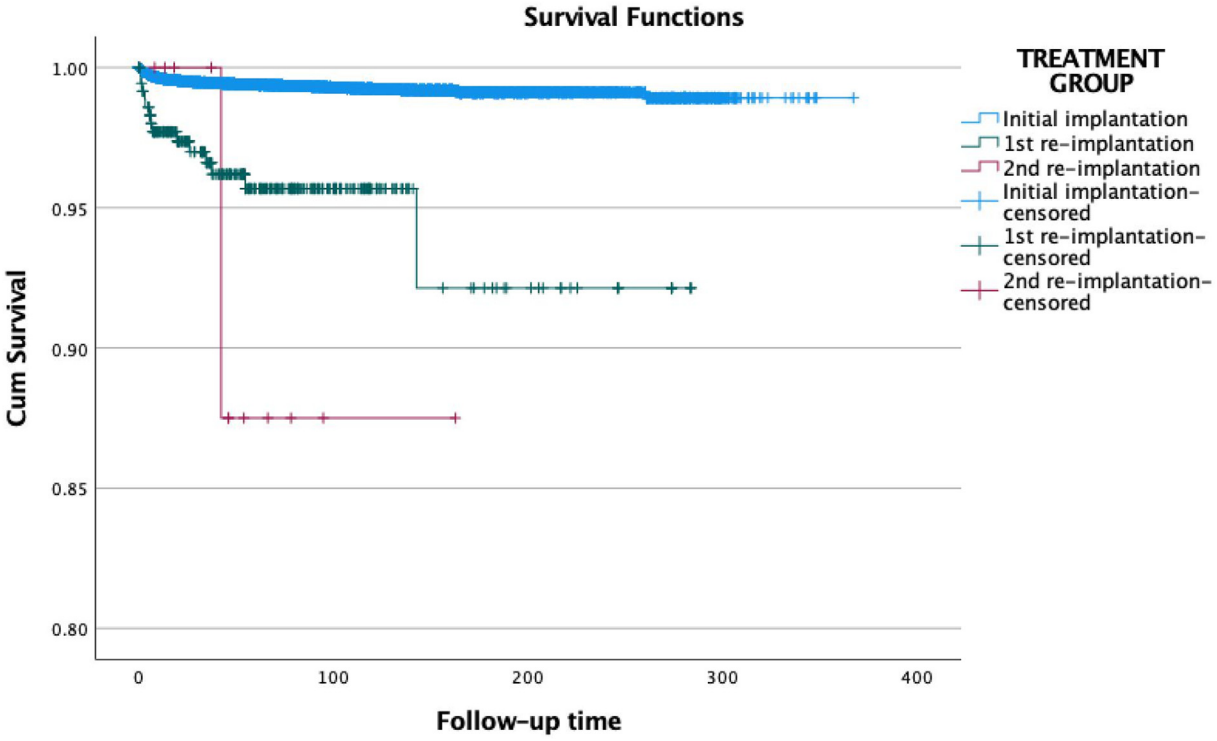

Figure 2 The Kaplan-Meier curves comparing the cumulative survival of initial implants placed (n = 50,333), 1st replacements/re-implantations (n = 358) and 2nd replacements/re-implantations (n = 12). Abbreviation: Cum Survival, cumulative survival.

replacements demonstrate three times higher risk of failure than initial implants ($P < 0.001$). Second replacements exhibit seven times greater risk of failure than the initially placed implants ($P = 0.05$), while no differences were detected between the 1st and 2nd replacements ($P = 0.415$). Similar findings have been reported in the literature namely that first implants exhibit significantly higher survival rates than second attempts and third attempts, while similar survival rates are found between second and third attempts.[24]

This study also aimed to identify patient-related factors associated with treatment outcome. Age, gender, ethnicity, race, smoking, marijuana use, a number of systemic factors including, hypertension, diabetes, thyroid disorder, HIV, kidney disease, arthritis, osteoporosis, depression, asthma and sleep apnea were all examined for patient association with implant failure in 1st re-implantations. None of these were significantly correlated with implant outcome. Similar findings have been reported in the literature which may indicate that previous implant failures outweigh patient and environmental factors.[19] Factors leading to initial implant failure may affect the survival of the first and second replacements. Implant failures were not concentrated in a specific group of patients, a phenomenon called "cluster failures" which therefore supports that patient-related factors do not affect treatment outcome. Site-specific parameters including arch (maxilla and mandible) and region (anterior and posterior) were examined and none of these exhibited a significant role in implant treatment outcome. Implant-specific effects have also been examined in the literature including implant surface, length as well as diameter and contradictory findings regarding these factors have been reported.[9,12,13,15,17,19–21,25,26]

The retrospective design of the present investigation should be considered when interpreting the results. Implant placements were performed by different clinicians within the participating institutions (Harvard University; University of Texas Health; The University of California, San Francisco; University of Colorado; Loma Linda University; University of Buffalo; The University of Iowa; The University of Minnesota; Tufts University between 2011 and 2022). Although there might be differences in the techniques used, all institutions follow specific implant protocols and use high quality implant systems. In addition, no information was available regarding implant and site characteristics including alveolar bone condition such as bone quality, type of bone (grafted or pristine), implant surface, diameter, length, or type of prosthesis. The experience of the implant surgeon (post-graduate student/resident or faculty) and the history of periodontal disease should be further investigated in the future. Future studies should include detailed information regarding implant and site parameters. Identifying risk factors associated with failure of successive re-implantations may enable clinicians to provide individualized implant treatment plans. A strength of this investigation was the evaluation of a large number of dental records of implants placed at different university dental clinics following evidence-based surgical and prosthetic implant protocols which increase the validity of the findings and eliminate selection bias. Another strength of the present study is the long follow-up time that included implants observed for up to 367 months which is much longer than previous research.

Within the limitations of the present study, it can be concluded that dental implants replacing failed implants exhibited lower survival rates than the rates found for the previous attempts of implant placement. No risk indicators for implant failure were identified. Additional factors should be examined in future studies to allow for proper planning when reimplantation is needed.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgments

This research was supported by a University of Minnesota School of Dentistry, Division of Periodontology grant (L.F.W.).

References

1. Buser D, Janner SF, Wittneben JG, Brägger U, Ramseier CA, Salvi GE. 10-year survival and success rates of 511 titanium implants with a sandblasted and acid-etched surface: a retrospective study in 303 partially edentulous patients. *Clin Implant Dent Relat Res* 2012;14:839—51.
2. Chappuis V, Buser R, Brägger U, Bornstein MM, Salvi GE, Buser D. Long-term outcomes of dental implants with a titanium plasma-sprayed surface: a 20-year prospective case series study in partially edentulous patients. *Clin Implant Dent Relat Res* 2013;15:780—90.
3. Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. *J Clin Periodontol* 2002;29:197—212.
4. Alsaadi G, Quirynen M, Komárek A, Steenberghe D. Impact of local and systemic factors on the incidence of oral implant failures, up to abutment connection. *J Clin Periodontol* 2007;34:61—7.
5. Quirynen M, De Soete M, Steenberghe D. Infectious risks for oral implants: a review of the literature. *Clin Oral Implants Res* 2002;13:1—19.
6. Dreyer H, Grischke J, Tiede C, et al. Epidemiology and risk factors of peri-implantitis: a systematic review. *J Periodontal Res* 2018;53:657—81.
7. Mombelli A, Müller N, Cionca N. The epidemiology of peri-implantitis. *Clin Oral Implants Res* 2012;23:67—76.
8. Schwarz MS. Mechanical complications of dental implants. *Clin Oral Implants Res* 2000;1:156—8.
9. Mardinger O, Ben Zvi Y, Chaushu G, Nissan J, Manor Y. A retrospective analysis of replacing dental implants in previously failed sites. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2012;114:290—3.
10. Levin L. Dealing with dental implant failures. *J Appl Oral Sci* 2008;16:171.
11. Machtei EE. What do we do after an implant fails? A review of treatment alternatives for failed implants. *Int J Periodontics Restor Dent* 2013;33:111—9.
12. Wang F, Zhang Z, Monje A, Huang W, Wu Y, Wang G. Intermediate long-term clinical performance of dental implants placed in sites with a previous early implant failure: a retrospective analysis. *Clin Oral Implants Res* 2015;26:1443—9.
13. Manor Y, Oubaid S, Mardinger O, Chaushu G, Nissan J. Characteristics of early versus late implant failure: a retrospective study. *J Oral Maxillofac Surg* 2009;67:2649—52.
14. Grossmann Y, Levin L. Success and survival of single dental implants placed in sites of previously failed implants. *J Periodontol* 2007;78:1670—4.
15. Chrcanovic BR, Kisch J, Albrektsson T, Wennerberg A. Survival of dental implants placed in sites of previously failed implants. *Clin Oral Implants Res* 2017;28:1348—53.
16. He J, Shang YW, Deng CF, et al. A clinical retrospective analysis of dental implants replaced in previously failed sites. *Shang Hai Kou Qiang Yi Xue* 2014;23:196—200.
17. Machtei EE, Horwitz J, Mahler D, Grossmann Y, Levin L. Third attempt to place implants in sites where previous surgeries have failed. *J Clin Periodontol* 2011;38:195—8.
18. Kim YK, Park JY, Kim SG, Lee HJ. Prognosis of the implants replaced after removal of failed dental implants. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;110:281—6.
19. Machtei EE, Mahler D, Oettinger-Barak O, Zuabi O, Horwitz J. Dental implants placed in previously failed sites: survival rate and factors affecting the outcome. *Clin Oral Implants Res* 2008;19:259—64.
20. Alsaadi G, Quirynen M, van Steenberghe D. The importance of implant surface characteristics in the replacement of failed implants. *Int J Oral Maxillofac Implants* 2006;21:270—4.
21. Quaranta A, Cicconetti A, Battaglia L, Piemontese M, Pompa G, Vozza I. Crestal bone remodeling around platform switched, immediately loaded implants placed in sites of previous failures. *Eur J Inflamm* 2012;10:115—22.
22. Anitua E, Piñas L, Begoña L, Alkhraisat MH. Prognosis of dental implants immediately placed in sockets affected by peri-implantitis: a retrospective pilot study. *Int J Periodontics Restor Dent* 2017;37:713—9.
23. Raghoebar GM, Meijer HJA, van Minnen B, Vissink A. Immediate reconstruction of failed implants in the esthetic zone using a flapless technique and autogenous composite tuberosity graft. *J Oral Maxillofac Surg* 2018;76:528—33.
24. Gomes GH, Misawa MYO, Fernandes C, et al. A systematic review and meta-analysis of the survival rate of implants placed in previously failed sites. *Braz Oral Res* 2018;32:27.
25. Kang DY, Kim M, Lee SJ, et al. Early implant failure: a retrospective analysis of contributing factors. *J Periodontal Implant Sci* 2019;49:287—98.
26. Derks J, Håkansson J, Wennström JL, Tomasi C, Larsson M, Berglundh T. Effectiveness of implant therapy analyzed in a Swedish population: early and late implant loss. *J Dent Res* 2015;94:44S—51S.