Journal of Oral Rehabilitation

Journal of Oral Rehabilitation 2017 **44**; 229–236

Review

Dental implant loss in older versus younger patients: a systematic review and meta-analysis of prospective studies

D. I. SENDYK*, E. S. ROVAI†, C. M. PANNUTI†, M. C. Z. DEBONI*, W. R. SENDYK‡ & A. WENNERBERG§ *Department of Oral and Maxillofacial Surgery, Faculty of Odontology, University of São Paulo, São Paulo, †Division of Periodontics, Department of Stomatology, Faculty of Odontology, University of São Paulo, São Paulo, ‡Department of Periodontology and Implantology, Faculty of Odontology, University of Santo Amaro, São Paulo, Brazil and §Department of Prosthodontics, Faculty of Odontology, Malmö University, Malmö, Sweden

SUMMARY **The aim of this systematic review was to evaluate implant loss in younger and older patients. An electronic search of four databases (MEDLINE, EMBASE, SCOPUS and the Cochrane Library) was undertaken until May 2016 without time restriction and was supplemented by manual searching. Prospective cohorts were included if they met the following criteria: (i) presence of an exposed group (older subjects) with a minimum age of 60 years; (ii) presence of a control group (younger subjects) with a maximum age of 59 years; and (iii) outcome data considering implant survival or loss. Meta-analyses were performed to evaluate the impact of ageing on implant failure. Of 4152 potentially eligible articles, four were included in the qualitative analysis and quantitative synthesis. The pooled estimates suggest that the risk of implant loss in older patients is not significantly higher (RR = 0·92; 95% CI 0·43–1·96, *P* = 0·83) when compared to younger subjects. This systematic review suggests that age is not a limiting factor for dental implant therapy.**

KEYWORDS: **dental implants, implant failure, implant loss, osseointegration, older adults, aged patient**

Accepted for publication 28 November 2016

Background

According to the RAND monograph prepared for the European Commission (1), almost all European countries are experiencing decreases in fertility rates and consequently the ageing of their populations. Fertility has fallen below the replacement level (2·1 children per couple). At the same time, the proportion of the elderly population continues to grow. In the United States, about one in every seven persons is considered an older American (2). These observations are particularly interesting, as elderly patients are the population group with the highest tooth loss ratio, and despite the significant reduction in edentulism, the rate of decline may be offset by population growth and ageing (3).

In this context, therapy with osseointegrated dental implants reveals an alternative to conventional restorations, such as complete or partial dentures, whose lack of stability, retention and decreased chewing ability are the main complaints of elderly patients (4). However, increased implant failure rates have been found in jaws with poor bone quality, due the difficulty in obtaining optimal initial stability and lack of mechanical resistance (5), a presentation more likely to be found in aged patients (6, 7).

Some medical conditions related to ageing should be considered when planning treatments with dental implants. Osteoporosis, a condition that increases with age, was shown to impair the process of osseointegration in an experimental model (8, 9). Further, at

doi: 10.1111/joor.12465

menopause, oestrogen-level reductions are associated with increased bone resorption (7, 10). In men aged 70 years or more, loss of mineral density can be observed (7).

A recent meta-analysis assessed the survival rates of implants in partially and completely edentulous jaws of elderly patients (11). However, the question arises as to whether these survival rates are lower than those observed in younger groups. A preliminary literature search revealed that the association between dental implant failure and ageing has been mainly described in observational retrospective studies. In these publications, the temporal relationship between exposure and outcome is difficult to assess. This characteristic of retrospective studies increases the risk of bias and reduces the strength of scientific evidence. Additionally, few studies reported the classification of patients into different age groups for comparison with respect to implant loss. Thus, this study aimed to systematically assess prospective cohort studies comparing dental implant loss in older and younger patients.

Material and methods

This systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (12) and registered in the International Prospective Register of Systematic Reviews – PROSPERO (CRD42016038591).

Focused question

According to the PICO framework:

> Is the rate of dental implant loss in older patients higher when compared to younger patients (controls)?

Inclusion and exclusion criteria

Due to the inability to randomise the risk factor of interest (i.e. ageing), only prospective cohort studies were included in this systematic review. Publications were included if they met the following eligibility criteria: (i) original studies in English; (ii) presence of an exposed group (older subjects) with a minimum age of 60 years; (iii) presence of a control group (younger subjects) with a maximum age of 59 years; (iv) at least 1 year of follow-up; and (v) outcome data considering implant survival or loss. Retrospective studies, letters to editors, reviews, case series, case reports, *in vivo* and *in vitro* studies were not included.

Search strategy

A systematic literature search was conducted in MEDLINE (PubMed), SCOPUS and the Cochrane Library database, until 9 May 2016. Publications were searched using the following keywords with Boolean operators to combine searches: (((((((elderly) OR geriatric) OR aged) OR older) OR age)) AND ((dental implant) OR oral implant)) AND (survival)). The authors also conducted a manual search of reference lists from identified studies.

In the first phase of the review, two independent reviewers (DIS and ESR) independently screened titles and abstracts identified by the search strategy. Disagreements were resolved by discussion with the inclusion of another review author (CMP). Studies that met the inclusion criteria or with unclear information in the title and abstract were selected for assessment of the full paper in the second phase of the review, which was conducted by the same reviewers. Reasons for the rejection of studies were recorded for each report.

Data extraction

Publications that met inclusion criteria had their data extracted using specially designed data-extraction forms (13). If data were missing, the authors of the original reports were contacted and asked to provide further details.

Quality assessment

The methodological quality of the observational studies included in this review was assessed using an adapted Newcastle-Ottawa scale (NOS) (14). Briefly, the reviewers considered the following points and questions: (i) selection of study groups (i.e. sample size calculation and representativeness of the elderly patients), training/calibration of assessors of the primary outcome (implant failure), demonstration that the outcome of interest was not provided before patient admission (i.e. prospective data collection) and description of clear inclusion/exclusion criteria; (ii)

comparability of subjects on the basis of the study design or analysis; (iii) outcome (ascertainment/criteria applied to confirm implant survival and adequacy of patient follow-up); and (iv) statistical analysis (i.e. validity of statistical analysis reported in the statistical model). The scores ranged from 0 to 14. Studies with 11–14 points were arbitrarily considered to be of high methodological quality, 8–10 points indicated medium quality, and <8 points suggested low quality.

Summary measures and synthesis of results

Analyses were performed using Review Manager (RevMan) software, version 5.3* . Random-effects meta-analyses were conducted for implant failure (dichotomous outcome). The estimates were presented as pooled risk ratios (RR) and their respective 95% confidence intervals (CIs). Statistical heterogeneity among studies was assessed with the Cochrane Q test and I^2.

Results

Search results and excluded trials

After reviewing the abstracts and titles of 4166 articles in the initial search, 173 studies were identified for data analysis by excluding publications covering unrelated topics and information. Of the total of identified studies, 169 were excluded because they did not fit all of the selection criteria. The reasons for exclusion were as follows: double publication, follow-up period less than 1 year, authors not reachable, retrospective, case–control and case-series studies, and absence of a younger control group. Four prospective studies met the eligibility criteria and were included in the statistical analysis (Fig. 1).

Description of the included studies

Data regarding characteristics of the included papers are shown in Table 1. The follow-up period ranged from 1 to 10 years. Smoking behaviour was reported in some patients (6, 15, 16) as was bruxism (15, 16). In total, 1152 implants were evaluated in all articles. Implants were from Nobel Biocare† , Straumann‡ , Dentsply Friadent§ and Leone Implant¶ . The types of surfaces tested were machined, TPS-coated, sand-blasted and acid-etched. The implant length varied from 8·0 to 13·0 mm, and implant diameter ranged from 3·3 to 4·8 mm. The prosthetic rehabilitation was complete-fixed dentures, overdentures, two-implant bar overdentures, partial-fixed and single-tooth replacements. No implants inserted into fresh extraction sockets or subjected to immediate loading were reported.

Quality assessment

All the included studies defined implant failure by well-accepted survival criteria, which included no implant loss, no mobility, no pain or discomfort, and absence of detectable bone loss (17). The mean NOS score was 9·5 ± 0·5 (range from 9 to 10) for the four included studies (Table 2). The four articles were considered of medium quality. None of the included papers reported sample size calculation or calibration of the outcome assessors. Only two studies reported control of confounders (6, 16). In all studies, the younger subjects were drawn from the same source as the older patients. All studies reported a small number of subjects lost, with more than 70% rates of complete follow-up. In all studies, both groups received the same implant therapy.

Meta-analysis

Meta-analysis was performed comparing the exposed group (older patients) with the control group (younger patients). The pooled estimates suggest that the risk of implant loss in older patients is not significantly higher (RR = 0·92; 95% CI 0·43–1·96, $P = 0·83$) when compared to younger patients (Fig. 2). Heterogeneity was low ($I^2 = 19\%$, $\chi^2 = 3·71$, $P = 0·29$).

Discussion

Summary of main results

Due to the inability to randomise the risk factor of interest, only prospective cohorts that compared older and younger patients were included in this review

*The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark.

†Zürich, Switzerland.

‡Basel, Switzerland.

§Mannheim, Germany.

¶Florence, Italy.

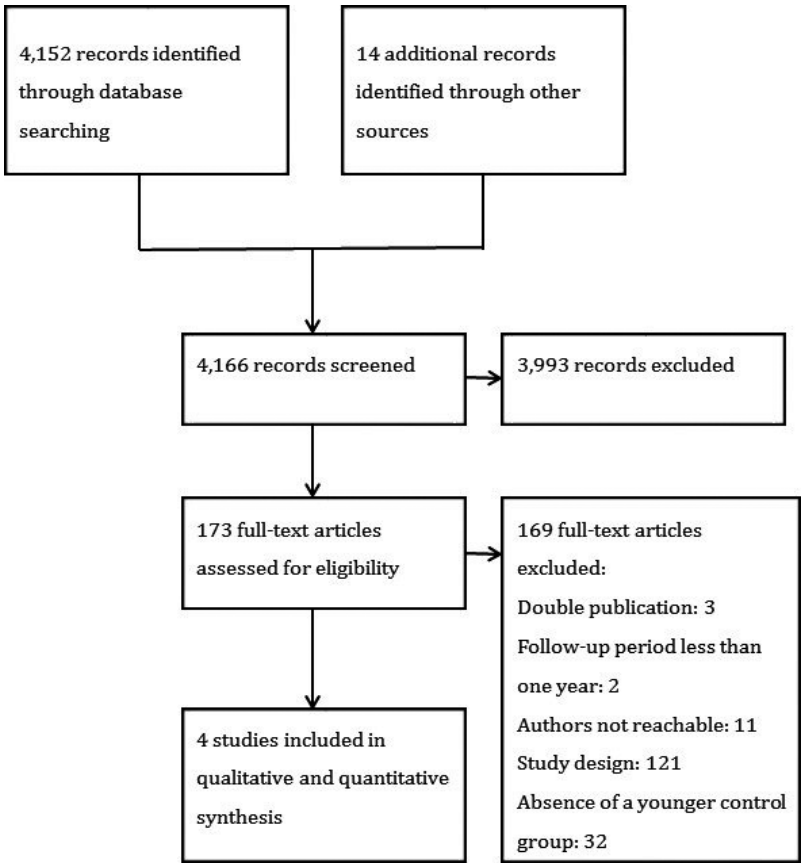

Fig. 1. Flow diagram of articles screened through the review process.

because the low methodological quality of retrospective studies could have biased the survival rates. The main result of this meta-analysis was that the rate of dental implant loss in older patients is not significantly higher when compared to younger controls. None of the four prospective trials observed any significant differences favouring younger patients. In addition, low heterogeneity (I^2 = 19%) between studies was found. Due to a small sample size, we could not achieve a reasonable number of patients to perform a systematic review with different age groups. Thus, we only included patients with more or less than 60 years.

Quality of evidence, limitations and potential biases in the review process

In this review, despite some important quality criteria being fulfilled (i.e. representativeness of the older and younger populations, demonstration that the outcome of interest was not presented at the start of study, adequacy of follow-up and valid statistical analysis), the four included studies were considered of moderate methodological quality, specifically, due to the lack of sample size calculation, masking of examiners and management of confounding factors, according to the Newcastle-Ottawa tool. Nevertheless, some inherent difficulties in fulfilling these quality criteria in these sorts of studies must be understood, especially patient recruitment and retention, which is particularly challenging in an older population. Further, it is difficult (if not impossible) to perform blind assessments of clinical conditions with regard to patient age.

Several important aspects must be highlighted regarding quality assessment. Some variables, such as implant location, bone quality and prosthetic rehabilitations, were not individually analysed and may impact the implant survival rate. Included studies reported several final prostheses, and the loading over implants may have been different. Furthermore, the implants used were from a variety of manufacturers

Table 1. Characteristic of the included studies

Author	Implant type	Follow-up	Groups according to patients age	Systemic and/or local conditions	Prosthetic rehabilitation	Implants placed/failure per group (N)
Bryant *et al.* (6)	374 Brånemark implants (Nobel Biocare, Göteborg, Sweden)	Average of 96 months for the older group and 120 for the younger group	<50 years ≥60 years	Smoking behaviour was reported by less than 20% of the patients in both groups	Complete-fixed, complete overdenture, partial-fixed and single-tooth replacements	<50 years: 184/24 ≥60 years: 190/15
Hoeksema *et al.* (4)	Two-stage IMZ cylinder implant (Dentsply Friadent, Mannheim); two-stage Brånemark screw implant (Nobel Biocare Holding AG, Zürich, Switzerland); one-stage ITI solid screw implant (Institut Straumann AG, Basel, Switzerland); and two-stage IMZ cylinder implant. Surgery was carried out in a one-stage procedure, reaching 210 implants	1, 5 and 10 years	≤50 years ≥60 years	Not reported	Two-implant bar-supported overdentures, with a conventional loading protocol	≤50 years: 104/3 ≥60 years: 106/7
Mangano *et al.* (15)	324 narrow-diameter (3·3 mm) implants (Leone Implant System, Florence, Italy)	Average of 5·4 years	≤54 years ≥65 years	46 were smokers and 28 had bruxing habits	Restorations consisted of single crowns, partial-fixed dentures, complete-fixed dentures and overdentures, with a conventional loading protocol	≤54 years: 230/2 ≥65 years: 19/0
Mangano *et al.* (16)	215 short-length (8 mm) implants, (Leone Implant System, Florence, Italy)	Average of 5·6 years	≤54 years ≥65 years	35 were smokers and 24 had bruxing habits	All restorations were single crowns, with a conventional loading protocol	≤54 years: 137/3 ≥65 years: 30/0

Table 2. Methodological quality of the included studies

	Bryant *et al.* (6)	Mangano *et al.* (15)	Mangano *et al.* (16)	Hoeksema *et al.* (4)
Selection (maximum 7)	4 ★	4 ★	4 ★	4 ★
Comparability (maximum 2)	2 ★	1 ★	2 ★	1 ★
Outcomes (maximum 3)	2 ★	2 ★	2 ★	2 ★
Statistics (maximum 2)	2 ★	2 ★	2 ★	2 ★
Total scores (maximum 14)	10	9	10	9

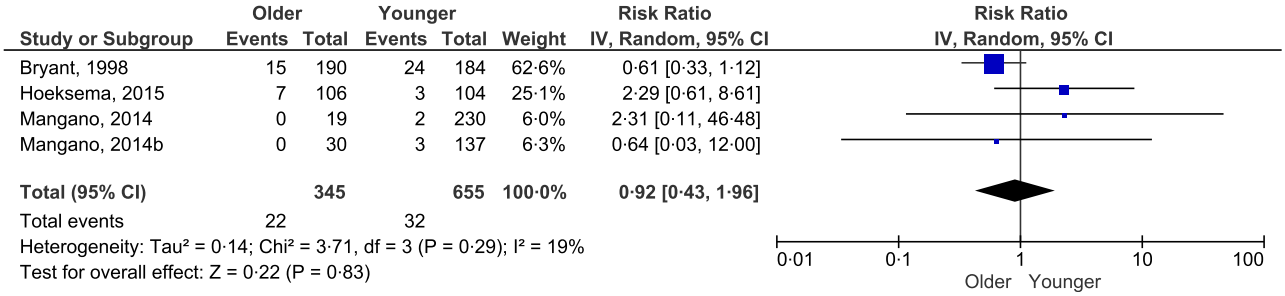

Fig. 2. Forest plot for the event 'implant failure' comparing older and younger patients. [Colour figure can be viewed at wileyonline library.com]

and surface treatments, including machined/turned implants.

All of the abovementioned characteristics should be accounted for when interpreting the findings of the present review. However, in spite of the present confounding factors and the moderate quality of the studies included in the meta-analysis, the outcome of these studies could be considered rather similar, in view of the low heterogeneity that was detected. We must emphasise that a small sample size of studies could have influenced the low heterogeneity.

Agreement and disagreement with other studies and reviews

A recent meta-analysis investigated the survival rates of dental implants in an elderly population (11). However, despite the notable work performed by the authors, only one of the included studies was a comparative prospective cohort with a younger control group (4), which was also identified in the present systematic review. In addition to that study, six studies were case series (2, 18–22), one was a case–control (23) and one publication (24) reported implants placed in fresh extraction sockets, which could have biased the results. Therefore, this systematic review is the first to include only comparative prospective cohorts with younger groups. Failure of dental implants in older patients is mainly described in observational retrospective studies. The lack of prospective cohorts must be associated with some innate obstacles such as following older patients over long periods, with few subjects completing the follow-up period.

The results of this systematic review support similar findings to previous observational cohorts (25–30), showing that age alone does not contraindicate implant placement, and successful rates can be achieved (2). A randomised clinical trial (31) is consistent with these results, suggesting that the osseointegration process was not impaired in elderly patients and may improve the maximum voluntary bite force and chewing efficiency with implant overdentures. Some retrospective cohorts (32–34) suggest a higher failure rate in older patients due to a possible association with systemic conditions, such as osteoporosis, decreased vascularity and decreased bone mass in post-menopausal woman. In all the included studies in the systematic review, patients with severe systemic diseases were excluded from the final samples. Smokers and patients with bruxism, when reported, were found in both the younger group and the older group and thus influenced the implant loss in all populations. None of the included studies reported an osteoporotic patient, and despite a recent systematic

review suggesting that osteoporosis can be correlated with higher rates of implant loss, the authors report less evidence to support this hypothesis (35).

One must be concerned that prospective cohorts commonly report as inclusion criteria patients without severe systemic conditions. Therefore, the sample of healthy ageing patients is smaller when compared with younger groups.

Interestingly, three retrospective cohorts reported higher failure rates in younger patients when compared to older subjects (36–38). However, these results may be associated with selection bias; for example, only healthier and more active older patients may seek implant treatment.

Conclusion

Within the limitations of this systematic review, it is reasonable to suggest that age is not a limiting factor in the planning of dental implant placement. However, more prospective comparative cohorts are required to further investigate the strength of this conclusion.

Acknowledgments

The authors would like to thank Dr. Francesco Guido Mangano for providing us with some important information about his studies. There was no source of funding for this systematic review. The authors have stated explicitly that there are no conflict of interests in connection with this article.

References

1. Grant J, Hoorens S, Sivadasan S, Van Het Loo M, DaVanzo J. Low fertility and population ageing: causes, consequences and policy options. Santa Monica (CA): RAND; 2004.
2. Becker W, Hujoel P, Becker BE, Wohrle P. Dental implants in an aged population: evaluation of periodontal health, bone loss, implant survival, and quality of life. Clin Implant Dent Relat Res. 2016;18:473–479.
3. Slade GD, Akinkugbe AA, Sanders AE. Projections of US edentulism prevalence following 5 decades of decline. J Dent Res. 2014;93:959–965.
4. Hoeksema AR, Visser A, Raghoebar GM, Vissink A, Meijer HJ. Influence of age on clinical performance of mandibular two-implant overdentures: a 10-year prospective comparative study. Clin Implant Dent Relat Res. 2016;18:745–751.
5. Chrcanovic BR, Albrektsson T, Wennerberg A. Reasons for failures of oral implants. J Oral Rehabil. 2014;41:443–476.
6. Bryant SR, Zarb GA. Osseointegration of oral implants in older and younger adults. Int J Oral Maxillofac Implants. 1998;13:492–499.
7. Dudley J. Implants for the ageing population. Aust Dent J. 2015;60:28–43.
8. Duarte PM, Gonçalves PF, Casati MZ, Sallun EA, Nociti FH. Age-related and surgically induced estrogen deficiencies may differently affect bone around titanium implants in rats. J Periodontol. 2005;76:1496–1501.
9. Du Z, Chen J, Yan F, Xiao Y. Effects of simvastatin on bone healing around titanium implants in osteoporotic rats. Clin Oral Implants Res. 2009;20:145–150.
10. Ikebe K, Wada M, Kagawa R, Maeda Y. Is old age a risk factor for dental implants? Jpn Dent Sci Rev. 2009;45:59–64.
11. Srinivasan M, Meyer S, Mombelli A, Müller F. Dental implants in the elderly population: a systematic review and meta-analysis. Clin Oral Implants Res. 2016;7:1–11.
12. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic review and meta-analyses: the PRISMA statement. J Clin Epidemiol. 2009;62:1006–1012.
13. Chambrone L, Chambrone D, Lima LA, Chambrone LA. Predictors of tooth loss during long-term periodontal maintenance: a systematic review of observational studies. J Clin Periodontol. 2010;37:675–684.
14. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M *et al.* The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses. Ottawa (ON): University of Ottawa. http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp.
15. Mangano FG, Shibli JA, Sammons RL, Veronesi G, Piattelli A, Mangano C. Clinical outcome of narrow-diameter (3.3-mm) locking-taper implants: a prospective study with 1 to 10 years of follow-up. Int J Oral Maxillofac Implants. 2014;29:448–455.
16. Mangano FG, Shibli JA, Sammons RL, Iaculli F, Piattelli A, Mangano C. Short (8 mm) locking-taper implants supporting single crowns in posterior region: prospective clinical study with 1-to 10-years of follow-up. Clin Oral Implants Res. 2014;25:933–940.
17. Albrektsson T, Zarb G, Worthington P, Eriksson AR. Long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants. 1986;1:11–25.
18. Ormianer Z, Palti A. Long-term clinical evaluation of tapered multi-threaded implants: results and influences of potential risk factors. J Oral Implantol. 2006;32:300–307.
19. Strietzel FP, Reichart PA. Oral rehabilitation using Camlog screw-cylinder implants with a particle-blasted and acid-etched microstructured surface. Results from a prospective study with special consideration of short implants. Clin Oral Implants Res. 2007;18:591–600.
20. Cakarer S, Can T, Yaltirik M, Keskin C. Complications associates with the ball, bar and locator attachments for implant-supported overdentures. Med Oral Patol Oral Cir Bucal. 2011;16:e953–e959.

21. De Carvalho BC, de Carvalho EM, Consani RL. Flapless single-tooth immediate implant placement. Int J Oral Maxillofac Implants. 2013;28:783–789.
22. Bressan E, Lops D. Conometric retention for complete fixed prosthesis supported by four implants: 2-years prospective study. Clin Oral Implants Res. 2014;25:546–552.
23. Laviv A, Levin L, Usiel Y, Schwartz-Arad D. Surviva of immediately provisionalized dental implants: a case-control study with up to 5 years follow-up. Clin Implant Dent Relat Res. 2010;12:e23–e27.
24. Covani U, Chiappe G, Bosco M, Orlando B, Quaranta A, Barone A. A 10-year evaluation of implants placed in fresh extraction sockets: a prospective cohort study. J Periodontol. 2012;83:1226–1234.
25. Ochi S, Morris HF, Winkler S. Patient demographics and implant survival at uncovering: dental implant clinical research group interim report no. 6. Implant Dent. 1994;3:247–251.
26. Lambert PM, Morris HF, Ochi S. The influence of smoking on 3-year clinical success of osseointegrated dental implants. Ann Periodontol. 2000;5:79–89.
27. Kinsel RP, Liss M. Retrospective analysis of 56 edentulous dental arches restored with 344 single stage implants using an immediate loading fixed provisional protocol: statistical predictors of implant failure. Int J Oral Maxillofac Implants. 2007;22:823–830.
28. Suito H, Tomotake Y, Watanabe M, Nagao D, Ishida Y, Ichikawa T. Survival of immediate implant restoration: a retrospective study through 9-year-observation. J Prosthodont Res. 2011;55:141–145.
29. Busenlechner D, Fürhauser R, Haas R, Watzek G, Mailath G, Pommer B. Long-term implant success at the Academy for Oral Implantology: 8-year follow-up and risk factor analysis. J Periodontal Implant Sci. 2014;44:102–108.
30. Balshi TJ, Wolfinger GJ, Stein BE, Balshi SF. A long-term retrospective analysis of survival rates of implants in the mandible. Int J Oral Maxillofac Implants. 2015;30:1348–1354.
31. Müller F, Duvernay E, Loup A, Vazquez L, Herrmann FR, Schimmel M. Implant-supported mandibular overdentures in very old adults: a randomized controlled trial. J Dent Res. 2013;92:154–160.
32. Moy PK, Medina D, Shetty V, Aghaloo TL. Dental implants failure rates and associated risk factors. Int J Oral Maxillofac Implants. 2005;20:569–577.
33. Jang HW, Kang JK, Lee K, Lee YS, Park PK. A retrospective study on related factors affecting the survival rate of dental implants. J Adv Prosthodont. 2011;3:204–215.
34. Demiralp KÖ, Akbulut N, Kursun S, Argun D, Bagis N, Orhan K. Survial rate of short, locking taper implants with a plateau design: a 5-year retrospective study. Biomed Res Int. 2015:1–8.
35. Giro G, Chambrone L, Goldstein A, Rodrigues JA, Zenobio E, Feres M *et al.* Impact of osteoporosis in dental implants: a systematic review. World J Orthop. 2015;18:311–315.
36. Geckili O, Bilhan H, Geckili E, Cilingir A, Mumcu E, Bural C. Evaluation of possible prognostic factors for the success, survival and failure of dental implants. Implant Dent. 2014;23:44–50.
37. Kowar J, Stenport V, Jemt T. Mortality patterns in elderly partially edentulous and edentulous patients treated with dental implants. Int J Prosthodont. 2014;27:250–256.
38. Jemt T, Kowar J, Nilsson M, Stenport V. Patterns of mortality in patients treated with dental implants: a comparison of patient age groups and corresponding reference populations. Int J Prosthodont. 2015;28:569–576.

Correspondence: Daniel Isaac Sendyk, Department of Oral and Maxillofacial Surgery, Faculty of Odontology, University of São Paulo, Av Prof. Lineu Prestes 2227, Butantã, São Paulo 05508-000, Brazil.
E-mail: dsendyk@terra.com.br