

Implant success rates in full-arch rehabilitations supported by upright and tilted implants: a retrospective investigation with up to five years of follow-up

Luca Francetti^{1,2}, Andrea Rodolfi^{1,2}, Bruno Barbaro^{1,2}, Silvio Taschieri^{1,2}, Nicolò Cavalli^{1,2}, Stefano Corbella^{1,2,*}

¹Università degli Studi di Milano, Department of Biomedical, Surgical and Dental Sciences, Research Centre in Oral Implantology, Milan, Italy

²IRCCS Istituto Ortopedico Galeazzi, Milan, Italy

Purpose: The aim of this retrospective study was to investigate the cumulative success rate, the implant survival rate, and the occurrence of biological complications in implants supporting full-arch immediately loaded rehabilitations supported by upright and tilted implants.

Methods: The clinical records and periapical radiographs of patients who attended follow-up visits were collected, and information was recorded regarding marginal bone loss resorption, the occurrence of peri-implant infectious diseases, and the implant survival rate. Implants were classified as successful or not successful according to two distinct classifications for implant success.

Results: A total of 53 maxillary and mandibular restorations including 212 implants were analysed, of which 56 implants were studied over the full five-year follow-up period. After five years, the cumulative success rate was 76.04% according to the Misch classification and 56.34% according to the Albrektsson classification. The cumulative implant survival rate was 100%, although one implant was found to be affected by peri-implantitis at the second follow-up visit.

Conclusions: The cumulative success rate of the implants dropped over time, corresponding to the progression of marginal bone resorption. The prevalence of peri-implantitis was very low, and the implant survival rate was not found to be related to the cumulative success rate.

Keywords: Bone resorption, Dental implants, Dental restoration failure, Implant-supported dental prosthesis, Peri-implantitis.

INTRODUCTION

The application of an implant-supported prosthesis to treat maxillary and mandibular complete edentulism is capable of having a major impact on patients' quality of life and on their masticatory and phonetic performance following the resolution of the functional limitations caused by edentulism [1-4].

However, severe atrophy of the jaws can limit the possibilities for placing dental implants. In such cases, the necessity to increase bone volume through grafting procedures could have a negative effect on the patient's perception of the treatment, as well as on the economic cost of treatment, due to the likelihood of a longer treatment time and the increased possibility of surgical complications, among other factors [5].

Under particular clinical conditions, the use of tilted implants combined with upright implants can be applied for the rehabilitation by fixed prosthesis of completely edentulous arches, thereby restoring masticatory and aesthetic functionality while avoiding the need

pISSN 2093-2278
eISSN 2093-2286



JPIS >
Journal of Periodontal
& Implant Science

Research Article

J Periodontal Implant Sci 2015;45:210-215
<http://dx.doi.org/10.5051/jpis.2015.45.6.210>

Received: Oct. 15, 2015

Accepted: Nov. 30, 2015

*Correspondence:

Stefano Corbella
IRCCS Istituto Ortopedico Galeazzi, Via R. Galeazzi,
4, 20161, Milan, Italy
E-mail: stefano.corbella@gmail.com
Tel: +39-0250319950
Fax: +39-0250319960

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>).

to perform bone grafting procedures [6, 7]. In this way, dental implants can support a full-arch prosthesis that may also compensate for the consequences of atrophy, with the goal of restoring adequate support to the lips and correcting the vertical dimension [8].

A number of studies have evaluated the clinical results of rehabilitations supported by a combination of tilted and upright implants [9–11]. This kind of restoration has been reported to have a high implant survival rate, ranging from 97.2% to 100%. However, technical and biological complications can occur, although appropriate interventions are capable of significantly limiting the prevalence of implant or prosthesis failure [12,13].

Significant debate has emerged regarding the definition of implant survival and success criteria for implants [14]. In general, we considered functional implants without evident mobility to have survived, in accordance with several studies that have used these criteria to validate both short- and long-term data [15–18]. However, the major limit of considering only this parameter is that an implant may still be in place even in the presence of peri-implantitis or severe hard and soft tissue recession that could, for example, lead to complete aesthetic failure [19,20]. Most of the criteria for implant success are related to bone resorption. Albrektsson and colleagues [21] revised the principles initially proposed by the National Institute of Health in 1979. The most important revision was related to the bone resorption rate, which should be less than 0.2 mm after the first year of loading. Another classification of implant success was proposed at the International Congress of Oral Implantology in 2008 [22]. The authors proposed that bone resorption of less than 2 mm, as detected through periapical radiographs, and the absence of any signs or symptoms of mobility after prosthetic loading should be the criteria for success. However, no classification for implant success or failure has been generally accepted.

The aim of this retrospective investigation was to explore the success and survival rate of implants supporting a full-arch rehabilitation using an immediate loading protocol in the treatment of maxillary or mandibular edentulism. Furthermore, the occurrence of biological complications was recorded and analysed.

MATERIALS AND METHODS

This retrospective clinical trial was performed following the principles articulated in the Helsinki Declaration and further modifications [23]. The Review Board of the Oral Implantology Research Centre of the Università degli Studi di Milano in Milan, Italy ap-

proved the study protocol in 2013 (Protocol 1. 2013).

The inclusion criteria were:

- Patients treated with full-arch rehabilitations supported by a combination of two tilted and two upright implants, with the prosthesis placed following an immediate loading protocol (within 48 hours from surgery), which was chosen in order to avoid the need for bone regeneration procedures in the posterior areas of the jaws;
- Patients who had radiological documentation in the form of periapical radiographs for each implant and for each follow-up visit;
- Patients whose clinical data demonstrated at least adequate oral hygiene (a full-mouth plaque score of less than 25% and a full-mouth bleeding score of less than 25%, calculated by computing the proportion of teeth surfaces presenting plaque and bleeding, respectively [24]).

The exclusion criteria were:

- Patients who were missing radiographs (either at baseline or at follow-up appointments) or clinical data;
- Patients who failed to attend the planned follow-up visits.

Outcomes

The primary outcome was the cumulative implant success rate (CSR) evaluated for each implant according to the classifications used in this study (Table 1): the Albrektsson classification [21] and the Misch classification [22]. Each implant was classified as successful or not successful after evaluation of the clinical records and the periapical radiographs, taken using a paralleling technique and an individual X-ray holder. All measurements were performed by two expert and calibrated operators (AR, SC) independently, and in cases of disagreement, a third operator was consulted. Measurements were made using the Image-J analysis software (NIH Image-J v.1.45s; US National Institute of Health, Bethesda, MD, USA).

The secondary outcomes were:

- The implant survival rate, based on a calculation of the number of functional implants;
- The occurrence of peri-implantitis. Peri-implantitis was defined as the presence of radiographic bone loss and clinical signs of marginal inflammation, such as bleeding on probing, swelling, and increased probing depth.

Statistical methods

The prevalence and incidence of unsuccessful implants and patients was computed for each 12-month time frame within the overall five-year follow-up period, as well as the implant survival

Table 1. Criteria for defining implant success.

Misch et al. [22]	Albrektsson et al. [23]
1. No pain or tenderness upon function	1. Absence of mobility
2. No mobility	2. Absence of any evidence of peri-implant radiolucency
3. Less than 2 mm of radiographic bone loss after initial surgery	3. Vertical bone loss be less than 0.2 mm annually following the implant's first year of service
4. No history of exudates	4. Absence of pain, infections, paraesthesia, or violation of the mandibular canal

rate. The life-table analysis method was used to compute cumulative success rates for both classifications and for both jaws [25]. Briefly, given n_i , the number of implants in the interval; d_i , the number of implants not successful in an interval; and w_i , the number of implants withdrawn; p_i , the probability of surviving during the interval, was computed as follows: $p_i = 1 - (d_i - n_i^*) / n_i$ where n_i^* is computed as $n_i^* = n_i - 0.5 * w_i$. The cumulative success rate was then $CSR = p_1 * p_2 * \dots * p_k$

Differences in the number of unsuccessful and successful implants depending on orientation (tilted or upright) and between the Misch and the Albrektsson classifications were computed using Fisher's exact test. P -values < 0.05 were considered to indicate statistical significance.

RESULTS

A total of 212 implants (53 full-arch rehabilitations) in 46 patients were evaluated in the first 12 months of follow-up. Eighty-eight implants supported maxillary restorations, while 124 supported mandibular restorations. Twenty-nine patients were female, and the mean age for all subjects was 61 ± 12 years at the time of the first follow-up visit.

The CSR five years after implant/prosthesis placement was 62% for maxillary implants and 82.6% for mandibular implants using the Misch classification (Table 2). When maxillary and mandibular restorations were considered together, the CSR was 97.92% after one year, 91.98% after two years, 86.62% after three years, 81.67%

after four years, and 76.04% after five years, using the Misch classification. Using the Albrektsson classification, the five-year CSR was 43.4% for maxillary implants and 63.6% for mandibular implants (Table 3). When maxillary and mandibular restorations were considered together, the CSR% was 90.95% after one year, 85.44% after two years, 78.08% after three years, 67.39% after four years, and 56.34% after five years, using the Albrektsson classification. One of the cases examined in the present study is presented in Figure 1.

One implant in one patient showed signs and symptoms of peri-implantitis in the 12–24-month time frame. The cumulative implant survival rate was 100% (Table 4).

No statistically significant differences were found in the success rate between tilted and upright implants. However, in the first 12 months of follow-up alone, a statistically significant difference was found between the number of implants classified as successful following the Misch classification and those classified as successful following the Albrektsson classification ($P = 0.0034$).

DISCUSSION

In the present retrospective investigation, the implant survival rate was 100%, whereas the CSR, determined using both classifications, dropped gradually over time, meaning that significant physiological changes took place even in the absence of a significant prevalence of peri-implant infectious disease, such as peri-implantitis.

The vast majority of implants judged as unsuccessful in each time frame showed a marginal bone resorption higher than judged

Table 2. Cumulative success rate for maxillary and mandibular restorations, following the classification of Misch [22].

	MAXILLA			MANDIBLE			MANIBLE+MAXILLA		
	No. of implants	NS	CSR	No. of implants	NS	CSR	No. of implants	NS	CSR
0-12 months	88	1	98.62%	124	3	97.49%	212	4	97.92%
12-24 months	56	5	89.57%	112	4	93.34%	168	9	91.98%
24-36 months	48	2	85.59%	72	4	86.90%	120	6	86.62%
36-48 months	40	2	79.69%	40	2	82.56%	80	4	81.67%
48-60 months	16	2	61.98%	40	0	82.56%	56	2	76.04%

NS, not successful; CSR, cumulative success rate.

Table 3. Cumulative success rate for maxillary and mandibular restorations, following the classification of Albrektsson [21].

	MAXILLA			MANDIBLE			MANIBLE+MAXILLA		
	No. of implants	NS	CSR	No. of implants	NS	CSR	No. of implants	NS	CSR
0-12 months	88	7	90.73%	124	11	91.09%	212	18	90.95%
12-24 months	56	2	87.30%	112	7	84.42%	168	9	85.44%
24-36 months	48	3	81.55%	72	6	75.83%	120	9	78.08%
36-48 months	40	7	63.43%	40	3	70.35%	80	10	67.39%
48-60 months	16	3	43.40%	40	2	63.65%	56	5	56.34%

NS, not successful; CSR, cumulative success rate.

Table 4. Incidence of peri-implantitis and implant survival rate.

	0-12 months	12-24 months	24-36 months	36-48 months	48-60 months
No. of peri-implantitis cases (implants)	0	1	0	0	0
Prevalence of peri-implantitis (implants)	0%	0.5%	0%	0%	0%
No. of peri-implantitis cases (patients)	0	1	0	0	0
Prevalence of peri-implantitis (patients)	0%	3.7%	0%	0%	0%
IMPLANT SURVIVAL (%)	100	100	100	100	100

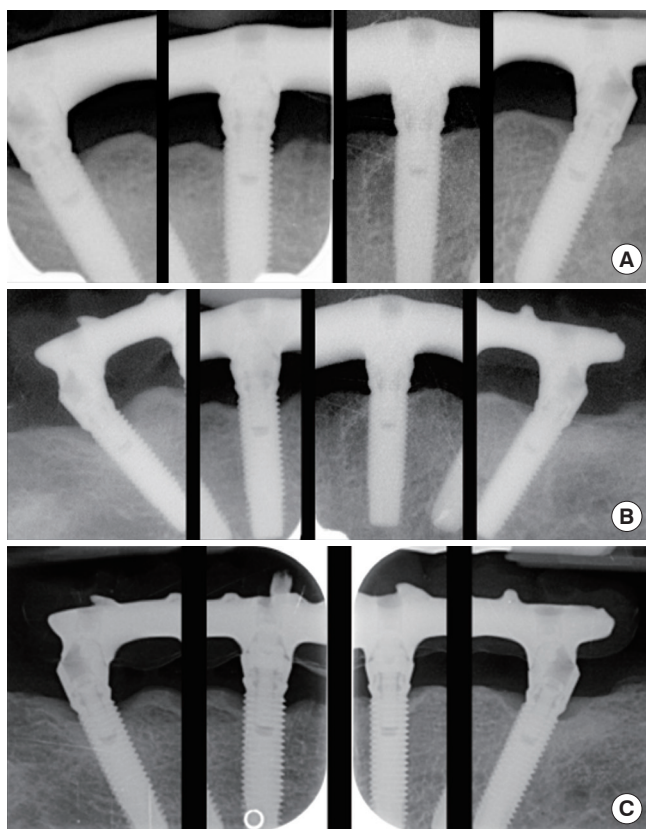


Figure 1. (A) Baseline findings of a patient. (B) Follow-up image taken three years after implant and prosthesis placement, showing no evidence of significant marginal bone resorption. (C) Follow-up examination at five years. No relevant marginal bone resorption was detected.

acceptable by a given classification. Nevertheless, marginal bone resorption was caused by peri-implantitis in only one implant in one subject. Therefore, in the other subjects, marginal bone resorption was most likely due to the physiological rearrangement of marginal bone over time.

A systematic literature review by Patzelt et al. [11] reported data about the same treatment strategy that was evaluated in this study. A total of 13 studies were included, and the reported implant survival rate at 12 months ranged from 97.2% for maxillary restorations [26] to 100%, which has been reported in multiple studies [15, 18,27-30]. With regard to marginal bone loss, previous studies have

generally reported no differences between upright and tilted implants, corresponding to the results of the present study. The reported pooled marginal bone loss was 0.9 ± 0.5 mm at 12 months, 0.9 ± 0.4 mm at 24 months, and 1.3 ± 0.4 mm at 36 months. These mean values of marginal bone resorption exceed the values proposed by Albrektsson and colleagues [21], which is why a lower number of successful implants was found using their classification than when the Misch classification was used [22].

Another systematic literature review focused on the differences in bone resorption between upright and tilted implants [9], reporting no statistically significant differences in a meta-analysis, which supports the results of our investigation. Moreover, the authors reported that, at 12 months of follow-up, the mean resorption rate for axial fixtures ranged from 0.43 ± 0.45 mm [31] to 1.13 ± 0.71 mm [32], while for tilted fixtures, it ranged from 0.34 ± 0.76 mm [33] to 1.14 ± 1.14 mm [32]. These results are comparable to those reported in other reviews.

Our study found no correlation between the CSR and the implant survival rate over time. An implant can be considered to have survived if it is still present in the mouth and supports a prosthesis, which is independent from the issue of potential hard and soft tissue resorption [34]. Therefore, the survival rate overestimates the true status of an implant and can be considered as of low significance in clinical practice.

In the present study, the occurrence of technical and biological complications was not analysed quantitatively.

Even though most technical and biological complications could be successfully treated without influencing the survival of the prosthesis, their occurrence may have been high, as reported in a previous literature review [13], and they could have had an impact on patients' perceptions of their treatment. In a previous study, prosthetic veneer fractures were reported to occur in 33.3% of patients after five years, while the occurrence of more than 2 mm of bone loss was reported in 20.1% of the 1,392 implants that were evaluated. Those results are comparable to the findings of our study using the Misch classification, confirming a tendency for marginal bone resorption over time.

Some limitations in the present study should be considered. First, the retrospective design of the protocol may have significantly limited the external validity of the results. Second, we chose to use two of the most commonly used classifications for implant success, but many others have been proposed [14], and no clear agreement

has been reached regarding this issue. Finally, the exclusion of some data due to incompleteness could have confounded our results.

In conclusion, considering the limitations of this study, we can conclude that implant success criteria did not reflect the actual condition of the implant-supported restorations, as marginal bone resorption was not associated with peri-implant infectious diseases. Implant loss was not related to the occurrence of a bone resorption rate higher than would be considered successful according to two commonly used sets of criteria for implant success.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ORCID

Luca Francetti <http://orcid.org/0000-0001-5775-8961>
Andrea Rodolfi <http://orcid.org/0000-0002-2352-9391>
Bruno Barbaro <http://orcid.org/0000-0001-8389-1942>
Silvio Taschieri <http://orcid.org/0000-0002-7866-5024>
Nicolò Cavalli <http://orcid.org/0000-0002-1091-7918>
Stefano Corbella <http://orcid.org/0000-0001-8428-8811>

REFERENCES

1. Allen F, McMillan A. Food selection and perceptions of chewing ability following provision of implant and conventional prostheses in complete denture wearers. *Clin Oral Implants Res* 2002;13:320-6.
2. Awad MA, Lund JP, Dufresne E, Feine JS. Comparing the efficacy of mandibular implant-retained overdentures and conventional dentures among middle-aged edentulous patients: satisfaction and functional assessment. *Int J Prosthodont* 2003;16:117-22.
3. Awad MA, Lund JP, Shapiro SH, Locker D, Klemetti E, Chehade A, et al. Oral health status and treatment satisfaction with mandibular implant overdentures and conventional dentures: a randomized clinical trial in a senior population. *Int J Prosthodont* 2003;16:390-6.
4. Heydecke G, Thomason JM, Lund JP, Feine JS. The impact of conventional and implant supported prostheses on social and sexual activities in edentulous adults Results from a randomized trial 2 months after treatment. *J Dent* 2005;33:649-57.
5. Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. *Int J Oral Maxillofac Implants* 2009;24 Suppl:237-59.
6. Maló P, Rangert B, Nobre M. "All-on-Four" immediate-function concept with Brånemark System implants for completely edentulous mandibles: a retrospective clinical study. *Clin Implant Dent Relat Res* 2003;5 Suppl 1:2-9.
7. Maló P, Rangert B, Nobre M. All-on-4 immediate-function concept with Brånemark System implants for completely edentulous maxillae: a 1-year retrospective clinical study. *Clin Implant Dent Relat Res* 2005;7 Suppl 1:S88-94.
8. Taschieri S, Corbella S, Francetti L, Del Fabbro M. Horizontal bone augmentation in full-arch maxillary implant-supported restorations: a preliminary clinical report. *Implant Dent* 2014;23:753-9.
9. Del Fabbro M, Ceresoli V. The fate of marginal bone around axial vs. tilted implants: a systematic review. *Eur J Oral Implantol* 2014;7 Suppl 2:S171-89.
10. Chrcanovic BR, Albrektsson T, Wennerberg A. Tilted versus axially placed dental implants: a meta-analysis. *J Dent* 2015;43:149-70.
11. Patzelt SB, Bahat O, Reynolds MA, Strub JR. The all-on-four treatment concept: a systematic review. *Clin Implant Dent Relat Res* 2014;16:836-55.
12. Francetti L, Corbella S, Taschieri S, Cavalli N, Del Fabbro M. Medium- and long-term complications in full-arch rehabilitations supported by upright and tilted implants. *Clin Implant Dent Relat Res* 2015;17:758-64.
13. Papaspyridakos P, Chen CJ, Chuang SK, Weber HP, Gallucci GO. A systematic review of biologic and technical complications with fixed implant rehabilitations for edentulous patients. *Int J Oral Maxillofac Implants* 2012;27:102-10.
14. Papaspyridakos P, Chen CJ, Singh M, Weber HP, Gallucci GO. Success criteria in implant dentistry: a systematic review. *J Dent Res* 2012;91:242-8.
15. Francetti L, Agliardi E, Testori T, Romeo D, Taschieri S, Del Fabbro M. Immediate rehabilitation of the mandible with fixed full prosthesis supported by axial and tilted implants: interim results of a single cohort prospective study. *Clin Implant Dent Relat Res* 2008;10:255-63.
16. Kwon T, Bain PA, Levin L. Systematic review of short- (5-10 years) and long-term (10 years or more) survival and success of full-arch fixed dental hybrid prostheses and supporting implants. *J Dent* 2014;42:1228-41.
17. Maló P, de Araújo Nobre M, Lopes A, Ferro A, Gravito I. All-on-4(R) treatment concept for the rehabilitation of the completely edentulous mandible: a 7-year clinical and 5-year radiographic retrospective case series with risk assessment for implant failure and marginal bone level. *Clin Implant Dent Relat Res* 2015;17 Suppl 2:e531-41.
18. Weinstein R, Agliardi E, Fabbro MD, Romeo D, Francetti L. Immediate rehabilitation of the extremely atrophic mandible with fixed full-prosthesis supported by four implants. *Clin Implant Dent Relat Res* 2012;14:434-41.
19. Chen ST, Buser D. Esthetic outcomes following immediate and early implant placement in the anterior maxilla--a systematic review. *Int J Oral Maxillofac Implants* 2014;29 Suppl:186-215.
20. Martin WC, Pollini A, Morton D. The influence of restorative procedures on esthetic outcomes in implant dentistry: a systematic review. *Int J Oral Maxillofac Implants* 2014;29 Suppl:142-54.
21. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants* 1986;1:

- 11-25.
22. Misch CE, Perel ML, Wang HL, Sammartino G, Galindo-Moreno P, Trisi P, et al. Implant success, survival, and failure: the International Congress of Oral Implantologists (ICOI) Pisa Consensus Conference. *Implant Dent* 2008;17:5-15.
 23. Krekmanov L, Heimdahl A. Bone grafting to the maxillary sinus from the lateral side of the mandible. *Br J Oral Maxillofac Surg* 2000;38:617-9.
 24. Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. *Int Dent J* 1975;25:229-35.
 25. Kim JS, Dailey RJ. *Biostatistics for oral healthcare*. 1st ed. Oxford: Blackwell Munksgaard; 2008.
 26. Malo P, de Araujo Nobre M, Lopes A. The use of computer-guided flapless implant surgery and four implants placed in immediate function to support a fixed denture: preliminary results after a mean follow-up period of thirteen months. *J Prosthet Dent* 2007; 97 Suppl:S26-34.
 27. Agliardi E, Clericò M, Ciancio P, Massironi D. Immediate loading of full-arch fixed prostheses supported by axial and tilted implants for the treatment of edentulous atrophic mandibles. *Quintessence Int* 2010;41:285-93.
 28. Capelli M, Zuffetti F, Del Fabbro M, Testori T. Immediate rehabilitation of the completely edentulous jaw with fixed prostheses supported by either upright or tilted implants: a multicenter clinical study. *Int J Oral Maxillofac Implants* 2007;22:639-44.
 29. Francetti L, Romeo D, Corbella S, Taschieri S, Del Fabbro M. Bone level changes around axial and tilted implants in full-arch fixed immediate restorations. Interim results of a prospective study. *Clin Implant Dent Relat Res* 2012;14:646-54.
 30. Landázuri-Del Barrio RA, Cosyn J, De Paula WN, De Bruyn H, Marcantonio E Jr. A prospective study on implants installed with flapless-guided surgery using the all-on-four concept in the mandible. *Clin Oral Implants Res* 2013;24:428-33.
 31. Aparicio C, Perales P, Rangert B. Tilted implants as an alternative to maxillary sinus grafting: a clinical, radiologic, and periotest study. *Clin Implant Dent Relat Res* 2001;3:39-49.
 32. Browaeys H, Dierens M, Ruyffelaert C, Matthijs C, De Bruyn H, Vandeweghe S. Ongoing Crestal Bone Loss around Implants Subjected to Computer-Guided Flapless Surgery and Immediate Loading Using the All-on-4(R) Concept. *Clin Implant Dent Relat Res* 2015;17:831-43.
 33. Calandriello R, Tomatis M. Simplified treatment of the atrophic posterior maxilla via immediate/early function and tilted implants: A prospective 1-year clinical study. *Clin Implant Dent Relat Res* 2005;7 Suppl 1:S1-12.
 34. Moraschini V, Poubel LA, Ferreira VF, Barboza ES. Evaluation of survival and success rates of dental implants reported in longitudinal studies with a follow-up period of at least 10 years: a systematic review. *Int J Oral Maxillofac Surg* 2015;44:377-88.