original article

Assessing the survival rates of dental implants in longitudinal studies with more than ten years of follow-up: a systematic review

Abstract / Objective: *To assess, by means of a systematic literature review, the survival rate of osseointegrated implants, in longitudinal studies with a follow-up exceeding 10 years.* Methods: *MEDLINE/PubMed, LILACS and Cochrane Collaboration were used to retrieve relevant publications published in indexed journals from the year 1981 on, in which the clinical performance of implants was assessed. Based on previously established inclusion and exclusion criteria, two reviewers assessed titles, abstracts and full papers giving priority to randomized controlled trials (RCTs).* Results: *A total of 16 articles were included in this review. Six prospective studies, seven retrospective studies and three randomized controlled trials, assessing 6,515 implants, were selected. The mean follow-up time was 13.4 years. Statistical analysis revealed a mean cumulative survival rate of 95.5 ± 4.2 (n = 6,515).* Conclusion: *The results of this systematic review revealed that implants have high success rates in the long-term, provided there is proper planning and patients are included in a thorough maintenance post-treatment program.*

Key words: *Dental implant. Longitudinal studies. Review.*

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INTRODUCTION

Before 1969, dental implant placement was carried out empirically, in other words, based on success and failure rates.[1] From 1965 on, after the discovery of osseointegration[2] and the first publication proving that it is possible to use screw-like titanium implants for implant-supported prostheses anchorage,[3] Implantodontics ceased to be an experimental science and became a well-understood and evidence-based science.

However, in order to render a given technique or material reliable and somehow predictable, longitudinal studies are necessary. Most longitudinal studies are based on a clinical follow-up focusing on implants survival rates. In other words, a quantitative analysis is carried out without discussing the biological or technological complications arising during the follow-up period.[4]

The first longitudinal studies assessing osseointegrated implants yielded satisfactory results.[5,6] Today, after 30 years of scientific evidence, the clinical use of implants has daily increased; however, only a few works have conducted a follow-up exceeding 10 years, which is essential to understand the long-term biological behavior of implants. In order to allow survival and success rates data to be duly assessed, a minimal of five years is advisable.[7]

While reading longitudinal studies about osseointegrated implants, one should be familiarized with some of the most frequently used terms. Thus, it is paramount to understand that "survival" only refers to the number or percentage of implants physically present at the placement site, regardless of their biological condition. In other words, it is nothing but a quantitative classification.[8] Those who advocate this method claim it is a simpler way of presenting study results.

The present study aimed at assessing, by means of a systematic literature review, the survival rate of osseointegrated implants, in longitudinal studies with a follow-up exceeding 10 years.

MATERIAL AND METHODS

The present systematic literature review was conducted according to steps based on scientific evidence[9] adapted from PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).[10]

Search strategy

An extensive electronic search was carried out from January, 2012 to February, 2014 on Washington National Library of Medicine data base (MEDLINE/PubMed) and Cochrane Central Register of Controlled Trials (CENTRAL) for relevant publications published in indexed journals. Search was conducted based on the following terms: [(endos$) OR (dental) OR (osseointegra$)] and [(implant$) OR (fixture$)] and [(prospective) OR (retrospective) OR (comparative) OR (longitudinal)].

Selection of studies

The following studies were selected:

» Human studies (complete or partial edentulous).

» Randomized controlled trials, prospective and retrospective studies.

» Studies assessing survival rates for at least 10 years.

Animal experimental studies, case reports, narrative reviews, studies including zygomatic implants, studies with patients subjected to radiotherapy, chemotherapy or using bisphosphonates, studies assessing

implants placed in bone regeneration sites and those assessing a specific group of patients (smokers, diabetics) were excluded.

Analysis of eligibility

During the research, a total of 2,240 titles written in English were selected. Of these, titles with no abstract available and not addressing the theme of the review were excluded. After the first analysis, 118 abstracts were retrieved. Thus, 40 full articles were selected for thorough reading. After assessing each article individually, a total of 16 studies, published between 1999 and 2012, and meeting the present study requirements, were selected. The process of selecting the studies is shown in Figure 1.

Data extraction

After a careful analysis, all studies selected were subjected to data extraction.

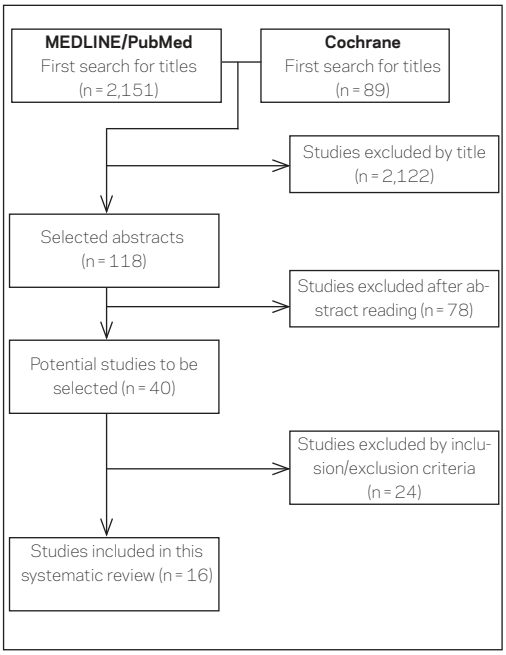

Figure 1. Process of selecting the studies.

To this end, the following characteristics of each study were considered: (1) author and year; (2) type of study; (3) number of participants; (4) average age; (5) sex; (6) follow-up duration; (7) number of implants; (8) implant system; and (9) survival rate.

Statistical analysis

A quantitative analysis followed by a meta-analysis could not be carried out by the present systematic review due to the different methods and results presented by the selected studies. This decision was made based on the justification that a meta-analysis should only be carried out when studies are similar enough so as to allow a comparative analysis.[12] Mean results were calculated by adding the total number of values observed divided by the total number of observations. In order to assess dispersion (variability) of individual values about the mean, standard deviation (SD) was estimated.

RESULTS

A total of 16 studies assessing implant success were included in the present review. The characteristics of each study are listed in Table 1. All studies conducted a follow-up exceeding 10 years. The mean follow-up time was 13.4 years. Six prospective, seven retrospective studies and three randomized controlled trials (RCTs) were selected.

Together the studies accounted for 1,714 patients aged between 13 and 90 years, and mean age of 54.4 ± 9.7. Of these, 777 (45.3%) were males while 937 (54.7%) were females.

A total of 6,515 implants of five different commercial brands, Astra Tech (Astra Tech AB, Mölndal, Sweden), Brånemark System (Nobel Biocare AB, Göteborg, Sweden), ITI (Straumann AG, Waldenburg,

Table 1. Studies included in the systematic review.

Autmor	Type of study	Number of participants	Mean age	Sex	Follow-up duration	Number of implants	Implant system	Survival rate (%)
Lekmolm et al,[20] 1999	Prospective	127	50	54m / 73f	10 years	461	NobelBiocare®	92,6
Carlsson et al,[16] 2000	Prospective	60	NR	16m /44f	15 years	348	NobelBiocare®	96
Van Steenbergme et al,[24] 2001	Retrospective	158	59.2	114m / 44f	12 years	316	NobelBiocare®	98,5
Leonmardt et al,[21] 2002	Prospective	15	NR	8m / 7f	10 years	57	NobelBiocare®	94,7
Karoussis et al,[19] 2004	Prospective	89	49.3	34m / 55f	12 years	179	ITI®	92,4
Telleman et al,[23] 2006	Retrospective	38	64	8m / 30f	10 years	115	ITI®	96,3
Jemt and Jomansson,[17] 2006	Retrospective	76	61.1	48m / 28f	15 years	450	NobelBiocare®	90,9
Romeo et al,[22] 2006	Retrospective	129	53	61m / 68f	14 years	265	ITI®	97,5
Åstrand et al,[15] 2008	Retrospective	21	54.3	7m / 14f	20 years	123	NobelBiocare®	99,2
Jemt,[18] 2008	RCT	114	42.7	74m / 40f	15 years	123	NobelBiocare®	97,7
Pikner et al,[6] 2009	Retrospective	640	52.3	255m / 385f	20 years	3.462	NobelBiocare®	98,2
Simonis et al,[8] 2010	Retrospective	55	68.7	21m / 34f	16 years	131	ITI®	83,7
Jacobs et al,[14] 2010	RCT	18	55.1	6m / 12f	16 years	95	NobelBiocare®, Astra Tecm®	93,9
Sunyoung et al,[26] 2010	RCT	106	65.3	40m / 66f	10 years	212	NobelBiocare®, Soutmern Implants®, Steri-Oss®	100
Gotfredsen,[25] 2012	Prospective	20	33	10m / 10f	10 years	20	Astra Tecm®	100
Degidi et al,[13] 2012	Prospective	48	49.9	21m / 27f	10 years	158	NobelBiocare®	97,2

NR = Not reported ; RCT = Randomized controlled trials , m = Males ; f = Females.

Switzerland), Southern Implants (Southern, Irvine, Canada) and Steri-Oss (Nobel Biocare AB, Göteborg, Sweden), and lengths varying from 6 to 13, 15,18,19 and 20 mm, were described. In terms of diameter, implants measuring 3.3, 3.75, 4.0, 4.8 and 5 mm were installed. Most studies used machined-surface implants; however, some of them used smooth-surface implants.

A total of 958 (14.7%) implants were installed in the upper arch, whereas 1,842 (27.9%) were installed in the lower arch. Nevertheless, three studies did not clearly report the placement site of 3,715 (57.4%) implants.[6,13,14]

The number of patients giving up or those who could not be followed up during the study period varied between 5 and 56%. One study did not report the number of patients giving up.[6]

In 13 studies,[6,8,14-24] implants were placed into healed sockets by means of a standard surgical protocol established in 1969.[1] In two studies,[13,25] immediate implants

were installed by means of immediate prosthetic loading. In one study, implants were placed into healed sockets; however, by means of early prosthetic loading.[26]

Implant survival

Of 6,515 implants originally installed, 205 were lost as a result of biological or mechanical complications. The mean survival rate based on the follow-up period is presented in Table 2. The mean cumulative survival rate was 95.5 ± 4.2% (n = 6,515), with variation of 83.7 to 100%. Approximately 70% of losses occurred after abutment placement and prosthetic loading.

DISCUSSION

In order to allow survival and success rates to be duly assessed, a minimal of five years of follow-up is required.[7] However, some authors advocate that a five-year period might be considered little reliable to assess information such as implant survival rate.[15]

The present systematic review revealed a mean survival rate of 95.5%, including a total of 6,515 implants, in 16 studies, with follow-up periods not greater than 20 years (mean follow-up of 13.4 years). Studies with longer follow-up periods (20 years)[6,15] had higher survival rates (98.7%). This result is in accordance with a previous study presenting a mean survival rate of 98.9% for a follow-up period of 20 years.[27]

As for implant length, one study concluded that shorter implants present a higher failure rate when compared to longer implants.[20] With a view to assessing the clinical performance of different types of implant, a systematic review including 10 randomized controlled trials was carried out in 2005.[28] After analyzing the articles, the authors concluded that there is no scientific evidence supporting that one type of implant presents long-term higher success or survival rates in comparison to others. Most studies used machined-surface implants. This choice is probably associated with the time when the studies were carried out.

Some articles concluded that there was a higher number of implant loss and bone resorption in smokers.[8,16] This conclusion is supported by other studies assessing the influence

Table 2. Survival rates based on follow-up periods.

Author	Survival rate (%)
10 years	
Lekholm et al.[20]	92.6
Leonhardt et al.[21]	94.7
Telleman et al.[23]	96.3
Sunyoung et al.[26]	100
Degidi et al.[13]	97.2
Gotfredsen[25]	100
Mean (SD)	**96.8 (2.93)**
12 years	
Van Steenberghe et al.[24]	98.5
Karoussis et al.[19]	92.4
Mean (SD)	**95.4 (4.3)**
14 years	
Romeo et al.[22]	**97.5**
15 years	
Carlsson et al.[16]	96
Jemt and Johansson[17]	90.9
Jemt[18]	97.7
Mean (SD)	**94.8 (3.53)**
16 years	
Simonis et al.[8]	83.7
Jacobs et al.[14]	93.9
Mean (SD)	**88.8 (7.2)**
20 years	
Åstrand et al.[15]	99.2
Pikner et al.[6]	98.2
Mean (SD)	**98.7 (0.7)**
Cumulative mean (SD)	**95.5 (4.2)**

of tobacco on implant survival.[29,30] Other factors mentioned as potentially contributing to implant failure, but which are not supported by the literature, are as follows: patients with systemic diseases, such as diabetes; patients with periodontal disease before implant therapy; implant placement in bone type III and IV; treatment carried out in elderly patients.

CONCLUSIONS

Based on the results of this systematic review it is reasonable to conclude that:

» There are only a few longitudinal studies assessing long-term osseointegrated implants performance.

» The present analysis revealed a mean survival rate of 95.5% within a mean follow-up period of 13.4 years.

» Approximately 70% of implant losses occurred after abutment placement and prosthetic loading, thus demonstrating that a higher number of failure occurs after implants are in function.

» Based on the analysis of studies included in the present review, it is reasonable to conclude that osseointegrated implants are safe and present high long-term survival rates, provided that there is proper planning and patients are included in a thorough maintenance post-treatment program.

REFERENCES:

1. Pompa CC, Ribeiro EDP, Sousa SB. Peri-implantite: diagnóstico e tratamento. Innov Implant J Biomater Esther. 2009;4(1):52-7.
2. Damé JAM, Resende DRB, Benfatti CAM, Sant ' Anna ACP, Greghi SLA, Passanezi E. Caracterização da superfície topográfica de protótipo de implante Ti cp submetido a tratamento semelhantes àqueles realizados para descontaminação em peri-implantites. Salusvita. 2003;22(3):343-52.
3. Colet D, Bandeira RP, Ernica NM, Huber HA. Peri-implantite: revisão de literatura. Dental Press Implantol. 2011;5(4):56-65.
4. Bottino MC, Tortamano IP, Valandro LF, Tortamano Neto P. Periimplantite: uma abordagem terapêutica. JBC: J Bras Clin Odontol Integr. 2005;9(48):66-72.
5. Rezende CP, Ramos MB, Daquila CH, Aeid Filho M, Dias MO, Denardin OVP. Peri-implantite. RGO: Rev Gaúch Odontol. 2005;53(4):321-4.
6. Parente EV, Gil JN, Klein RF, Trentini N, Camarini ET, Leite PCC. Periimplantite: revisão da literatura. ImplantNews. 2007;4(4):393-8.
7. Novaes Júnior AB, Oliveira RR, Borges GJ. Tratamento das doenças periimplantares: mucosite e periimplantite – parte 2: terapia reconstrutiva. Periodontia. 2008;18(4):70-7.
8. Sobreira FMS, Souza Júnior GR, Lopes NMA, Vildes A, Cimões R. Peri-implantite: bases científicas para diagnóstico e tratamento. Int J Dent. 2011;10(3):180-5.
9. Melo L, Vitussi TRC, Andrade JA, Walter KG, Ferrari DS, Shibli JA. Microbiologia das doenças periimplantares: revisão de literatura. Rev Odontol UNESP. 2007;36(1):61-9.
10. Francio L, Sousa AM, Storrer CLM, Deliberador TM, Sousa AC, Pizzatto E, et al. Tratamento da periimplantite: revisão de literatura. RSBO Rev Sul-Bras Odontol. 2008;5(2):75-81.
11. Mombelli A. Etiology, diagnosis, and treatment considerations in peri-implantitis. Curr Opin Periodontol. 1997;4:127-36.
12. Mombelli A, Lang NP. The diagnosis and treatment of peri-implantitis. Periodontol 2000. 1998;17:63-76.
13. Lang NP, Mombelli A, Tonetti MS, Bragger U, Hammerle CH. Clinical trials on therapies for peri-implants infections. Ann Periodontol. 1997;2:343-56.
14. Grunder U, Hurzeller MB, Schupbach P, Strub JR. Treatment of ligature induced peri-implantitis using guided tissue regeneration: a clinical and histologic study in the Beagle dog. Int Oral Maxillofac Implants. 1993;8(3):282-93.
15. Cerbasi KP. Etiologia bacteriana e tratamento da peri-implantite. Innov Implant J Biomater Esther. 2010;5(1):50-5.
16. Lang NP, Berglundh T. Peri-implant diseases: where are we now? Consensus of the Seventh European Workshop on Periodontology. Working Group 4 of Seventh European Workshop on Periodontology. J Clin Periodontol. 2011;38(Suppl 11):178-81.
17. Lindhe J, Meyle J. Peri-implant diseases: consensus report of the sixth European Workshop on Periodontology. J Clin Periodontol. 2008;35(suppl 8):282-5.
18. Cury PR, Martins M, Bonecker M, Araujo NS. Incidence of periodontal diagnosis in private dental practice. Am J Dent. 2006;10(3):163-5.
19. Lindh C, Oliveira GHC, Leles CR, Freire MCM, Ribeiro-Rotta RF. Bone quality assessment in routine dental implant treatment among Brazilian and Swedish specialists. Clin Oral Implants Res. 2013 Aug 6. doi: 10.1111/clr.12221. [Epub ahead of print].
20. Mombelli A, Lang NP. Antimicrobial treatment of peri-implant infections. Clin Oral Implants Res. 1992;3(4):162-8.
21. Persson LG, Ericsson I, Berglundh T, Lindhe J. Guided bone regeneration in the treatment of periimplantitis. Clin Oral Implants Res. 1996;7(4):366-72.
22. Roos-Jansaker AM, Lindahl C, Persson GR, Renvert S. Long-term stability of surgical bone regenerative procedures of peri-implantitis lesions in a prospective case-control study over 3 years. J Clin Periodontol. 2011;38(6):590-7.
23. Esposito M, Murray-Curtis L, Grusovin MG, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different types of dental implants. Cochrane Database Syst Rev. 2007;17(4):CD003815.
24. Wennerberg A, Albrektsson T, Andersson B. Bone tissue response to commercially pure titanium implants blasted with fine and coarse particles of aluminum oxide. Int J Oral Maxillofac Implants. 1996;11(1):38-45.
25. Boyan BD, Bonewald LF, Paschalis EP, Lohmann CH, Rosser J, Cochran DL, et al. Osteoblast-mediated mineral deposition in culture is dependent on surface microtopography. Calcif Tissue Int. 2002;71(6):519-29.
26. Togashi AY, Cirano FR, Lima LAPA. The role of implant surface chemistry in biological bone response. RPG: Rev Pós Grad. 2006;13(4):336-40.