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PATRICIA TOLENTINO DA ROSA DE SOUZA

DO SHORT IMPLANTS HAVE SIMILAR SURVIVAL RATES COMPARED TO STANDARD IMPLANTS IN POSTERIOR SINGLE CROWN?: A SYSTEMATIC REVIEW AND META-ANALYSIS.

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Orientadora: Prof. Dr. Luciana Reis Azevedo Alanis

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TERMO DE APROVAÇÃO

PATRICIA TOLENTINO DA ROSA DE SOUZA

IMPLANTES CURTOS POSSUEM TAXA DE SUCESSO SIMILAR AOS CONVENCIONAIS EM COROAS UNITÁRIAS POSTERIORES? REVISÃO SISTEMÁTICA E METANÁLISE

Dissertação apresentada ao Programa de Pós-Graduação em Odontologia da Pontifícia Universidade Católica do Paraná, como parte dos requisitos parciais para a obtenção do Título de **Mestre em Odontologia**, Área de Concentração em **Multidisciplinaridades em Saúde com Ênfase em Biociências.**

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Curitiba, 24 de outubro de 2018.

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SUMÁRIO

Do short implants have similar survival rates compared to standard implants in posterior single crown? A systematic review and meta-analysis.*

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ABSTRACT

Background: Short implants have been presented as an option for posterior rehabilitation in cases of poor bone height.

Purpose: To compare the survival rate of short implants and standard implants when used in posterior single crowns, in addition to reporting marginal bone loss, prosthetic failures, and surgical complications.

Materials and methods: Electronic search (PubMed, LILACS, Cochrane Library, Scopus and Web of Science) and hand search were performed to identify all randomized controlled trials (RCTs) and controlled clinical trials (CCTs) that evaluated both short and standard implants in posterior single crowns.

Results: Out of 345 articles identified by both electronic and hand search, four studies were selected (one CCT and three RCTs). The meta-analysis for the survival rate showed that there was no significant difference between the short implants and the standard ones (P=1.00; RR:1.00; CI:0.97-1.03) performed with three RCTs for a one-year follow-up. The mean marginal bone loss ranged from 0.1mm to 0.54mm. Only one study reported the presence of prosthetic failures and surgical complications.

Conclusions: The survival rate of short implants was similar to the standard ones in posterior single crowns, for the one-year follow-up period. They also presented low surgical complications, prosthetic failures and marginal bone loss, being a predictable treatment for single rehabilitation in posterior tooth loss.

Key words: systematic review, short dental implants, single crown, meta-analysis.

INTRODUCTION

The replacement of missing teeth by osseointegrated implants has become an effective treatment in the rehabilitation of partially and totally edentulous patients.[1,2] However, the placement of standard implants in some regions may be limited due to poor bone height.

In the posterior region of the edentulous mandible, bone height is decreased due to resorption caused by dental loss, resulting in proximity of the mandibular canal in relation to the alveolar bone crest.[3] There are some options for allowing the use of standard implants when this situation occurs,[4] such as guided bone regeneration,[5] onlay and inlay bone graft,[6] distraction osteogenesis,[7] and nerve lateralization.[8] Autogenous grafts, interpositional graft, like sandwich technique, and guided bone regeneration with membranes have a good success rate but there are also some disadvantages due to donor site morbidity, when autogenous bone is used, increased treatment time and high cost, in addition to some loss of bone graft height that may occur.[5,9–11] The osteogenic distraction is described as an advantageous technique, but its use is rendered unfeasible by the high cost of the appliance.[7] Moreover, the neurovascular bundle lateralization presents a high frequency of postoperative complications, such as paresthesia.[12,13] When tooth loss occurs in the posterior region of the maxilla, ridge resorption and sinus pneumatization decrease the bone height for rehabilitation with standard implants.[14] Maxillary sinus augmentation is a popular technique widely used to increase bone height for posterior implant placement leading to excellent results, and some modifications have been introduced over the years to minimize morbidity

and improve success.[15,16] Therefore, low residual ridge height has been one of the indications to the alternative use of short implants in posterior edentulous jaws.

The use of short implants has been presented as a predictable option for posterior rehabilitation because it reduces the number of surgeries, time of treatment and cost, besides reducing complications and morbidities that may result from the above mentioned surgical procedures.[4,17] In both maxilla and mandible, short implants have demonstrated an excellent survival rate when compared to standard implants used in grafted regions; the most frequent use of short implants occurs in cases that need more than one implant, in splinted prosthesis.[18,19] Prospective clinical studies using only short implants in posterior single crowns, without assessment of standard implants, have shown good results with a survival rate above 90%.[20–22] Systematic reviews have demonstrated excellent clinical performance of short implants in both single crowns and splinted prosthesis.[18,19,23,24]

The use of short implants was conservative at the beginning of the last decade, being indicated for good quality bone and in splinted prosthesis. It occurred because the success rate of short implants was lower than standard implants, due to the fact that their surface was machined.[25] With the development of technology and some studies in oral implantology, the characteristics of the implants were improved so that the implant acquired better performance. The development of surface treatment and the presence of micro threads in the cervical portion of the implant have optimized the long-term stability of the implants in function by means of greater bone-implant contact.[26,27] The switching platform has decreased marginal bone loss,[28] and a variety of thread design and more

aggressive implant shape have been developed for better primary stability in worse bone quality.[29] Thus, the short implant has been gaining more credibility, although it may still present a risk of mechanical failure due to a discrepancy in the crown-to-implant ratio, which in turn may be compensated by a wide diameter.[30–32]

There is still a controversy regarding the classification of short implants. Short implants were classified as those < 10 mm.[33,34] Moreover, recent studies classify short implants as ≤ 8 mm.[35,36] With the evolution and better performance of these implants, there is a tendency to include a new class of implants - ultra short implants ≤ 6 mm.[37] In this review, the most actual classification for short implants (≤ 8 mm) will be considered.

Systematic reviews have been conducted to better evaluate and compare results of studies with both short and standard implants. Some reviews compared short implants with standard implants using either splinted fixed prosthesis or single crowns;[24,36] all of them reporting favorable results for the short implants. There is also a systematic review reporting excellent performance of the short implants when compared to standard implants in grafted regions, which includes clinical studies with splinted prosthesis.[35] A systematic review published in 2014 evaluated studies with short implants in single crowns, but the failure reported by the authors was not to obtain randomized or controlled clinical trials.[38] From 2014, some randomized clinical trials with short implants and standard implants were carried out in posterior single crowns,[39–41] which instigated the elaboration of this review.

Therefore, the objective of this study was to evaluate if short implants (≤ 8 mm) have a success rate similar to standard implants when used in posterior

single crowns. In addition, another objective was to report and analyze, when present in the studies, marginal bone loss, surgical complications and prosthetic failures.

MATERIALS AND METHODS

In this systematic review, the protocol based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes)[42] was followed.

Focus question

Do short implants have similar survival rates compared to standard implants in posterior single crown, in a minimum 12-month follow-up period after function?

Population of studies

Healthy patients rehabilitated with posterior single crowns on dental implants.

Types of interventions

Test group: short implants (≤ 8 mm) in posterior single crowns in function.

Control

Control group: implants longer than 8 mm in regions with or without bone graft, with posterior single crowns in function.

Outcome

Primary: survival rate of implants with single crowns;

Secondary: presence of marginal bone loss, prosthetic failures, and surgical complications.

Inclusion criteria

The studies included in this review followed the criteria below:

• Randomized clinical trial (RCT) or controlled clinical trial (CCT) comparing short implants with standard implants in grafted regions or not, in posterior single crowns;

• At least 12 months of follow-up after placement of the crown;

• Studies published in English.

Exclusion criteria

The studies that included the following items were excluded from this review:

• *In vitro* studies;

• Animal studies;

• Retrospective studies;

• Cohort studies;

• Case report;

• Studies that considered short implants longer than 8 mm;

• Studies that had duplicity of patients.

Search Strategy

Electronic search in MEDLINE (PubMed), LILACS, Cochrane Library, Scopus and Web of Science was carried out covering studies published in the period between July 1996 and January 2018 in order to find all valid prospective studies associated with the subject of short implants and single crowns.

The search strategy was as follows:

("dental implants"[Mesh] OR "dental implant" OR "implant" OR "implants") AND (“single crown” OR “single crown implant” OR "single-tooth" OR "single prosthesis" OR "unitary prosthesis") AND (“reduced implant length” OR “short length implant" OR “short dental implant" OR “short implant" OR “ultra-short implant" OR “short implant length" OR “implant length (≤ 8mm)” OR “short dental implant maxilla” OR “short dental implant mandible” OR “reduced implants length” OR “short length implants" OR “short dental implants" OR “short implants" OR “ultra-short implants" OR “short implants length" OR “implants length (≤ 8mm)” OR “short dental implants maxilla” OR “short dental implants mandible”).

The hand search was conducted in the relevant dental journals (Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, European Journal of Oral Implantology, Implant Dentistry, International Journal of Oral and Maxillofacial Implants, International Journal of Oral and Maxillofacial Surgery, International Journal of Periodontics and Restorative Dentistry, International Journal of Prosthodontics, Journal of Clinical Periodontology, Journal of Dental Research, Journal of Dentistry, Journal of Oral and Maxillofacial Surgery, Journal of Periodontology) and the publications of the last five years were checked.

Selection of studies

Two reviewers (P.T.R.S. and M.B.A.M.) independently evaluated all titles and abstracts of the electronic search and used the inclusion criteria to select the studies. Based on a table drawn up by the two reviewers, after reading the titles and abstracts, a discussion was held to reach consensus if the study would be excluded. Studies that did not present explicit inclusion criteria in the abstract were

read in full to consider their inclusion or not in the systematic review. In case of doubts after evaluation and selection of the complete studies by the two reviewers, a third reviewer (L.R.A.A.) was activated to reach a common agreement. Thus, a final list of studies was formed which was assessed by the two reviewers based on the risk of bias in order to obtain the quality of the studies.

Quality assessment

The two reviewers independently assessed the quality of the methodology used in the review trials using the Cochrane Collaboration´s tool that assesses risk of bias in randomized clinical trials.[43] The studies were evaluated as low risk, unclear risk and high risk of bias, according to the parameters random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting and other bias (follow-up time).

Data extraction and method of analysis

Data from the included studies were collected by a reviewer (P.T.R.S.) with the use of a data extraction table. A second author (L.R.A.A.) checked all data collected from the studies. In case of doubts in data collection, a third reviewer (M.B.A.M.) was activated to reach a common agreement.

The data extraction table was elaborated according to the objective of this review: the survival rate of the implants was the primary outcome variable, and marginal bone loss (MBL), prosthetic failures and surgical complications were secondary outcomes variables.

Statistical analysis

The software Rev Man, version 5.3 (Reviewer Manager software: The Nordic Cochrane Center, The Cochrane Collaboration´s, Copenhagen, Denmark) was used to perform the meta-analysis, which was based on the Mantel-Haenszel analysis method to evaluate the survival rate of the posterior implants.

RESULTS

Search and analysis of studies

In the electronic database, 338 studies were detected, as shown in figure 1. After removal of duplicates and addition of studies found by hand search, 223 articles were carefully evaluated by two independent reviewers, with the aid of a table containing the criteria of inclusion. After discussion between the two examiners and exclusion of studies that did not meet the inclusion criteria of this systematic review, 34 articles were selected. The two reviewers read the 34 articles in full and analyzed for the exclusion criteria. Figure 1 shows all the reasons for exclusion of 30 studies and table 1 shows these excluded studies with their reasons.[2,34,51–60,41,61–69,44–50] Finally, four studies were selected for qualitative analysis.[39,40,70,71] One article was excluded from the quantitative analysis because it was not randomized and did not have a description of the exact number of implants in each evaluated group.[39]

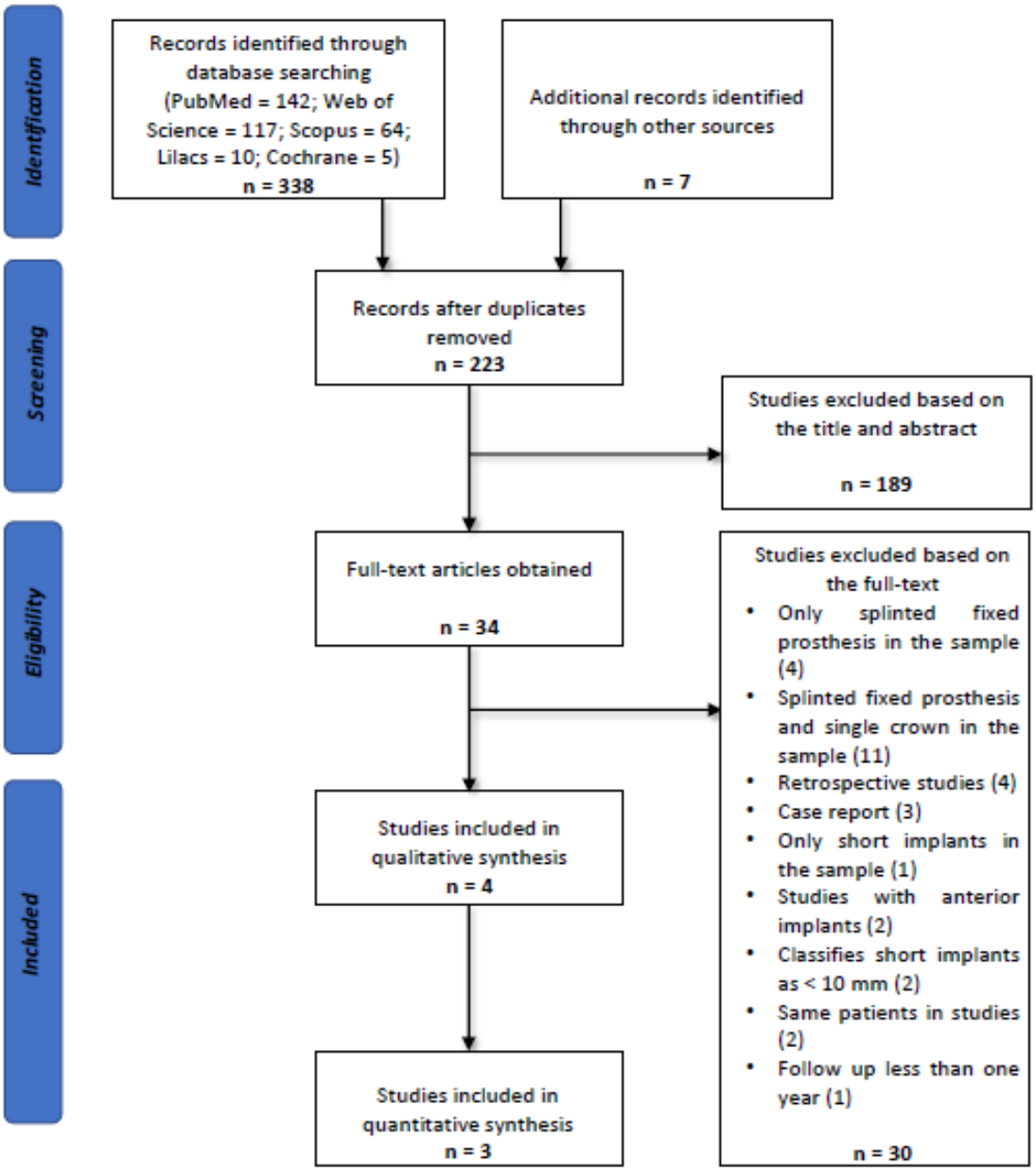

Figure 1. Flow diagram of the search strategy.

Table 1. Excluded studies and reasons for exclusions.	
Only splinted fixed prosthesis in the sample	
Felice et al.[63]	2015
Pistilli et al.[64]	2012
Esposito et al.[65]	2011
Esposito et al.[66]	2011
Splinted fixed prosthesis and single crown in the sample	
Pommer et al.[67]	2016
Malmstrom et al.[68]	2016
Vandeweghe et al.[69]	2011
Becker et al.[44]	2013
Nedir et al.[45]	2004
Naert et al.[46]	2002
Testori et al.[47]	2002
Hallman[48]	2001
Cune et al.[49]	2001
Teixeira et al.[50]	1997
Saadoun et al.[51]	1996
Retrospective studies	
Birdi et al.[52]	2010
Koo et al.[53]	2010
Degidi et al.[54]	2007
Polizzi et al.[55]	2000
Case reports	
Calvo-Guirado et al.[56]	2016
Marincola et al.[57]	2015
Santagata et al.[58]	2010
Only short implants in the sample	
Al-Hashedi et al.[59]	2016
Studies with anterior implants	
Weng et al.[25]	2003
Testori et al.[2]	2001
Short implants classified as < 10 mm	
Sullivan et al.[60]	2001
Deporter et al.[34]	2001
Same patients in studies*	
Schincaglia et al.[41]	2015
Thoma et al.[61]	2015
Follow-up less than one year	
Zhang et al.[62]	2017

* Both studies (Schincaglia et al., 2015); Thoma et al., 2015) have the same patients that were studied by Pohl et al. (2017), which was included in this review.

Description of included studies

Table 2 shows the characteristics of the four studies included in this systematic review, of which three were RCTs and one was a CCT. In total, 269 patients with a mean age of 47.8 years received 311 implants from October 2002 to January 2014. Two studies evaluated implants only in the maxilla.[70,71] The study by Rossi et al.[40] evaluated implants in both arches as well as the study of Mendoza-Azpur et al.,[39] but the latter did not specify the exact number of implants in each arch and in each group.

Table 2. Information and characteristics of the included studies.

Author (year)	Study Design	Patients (patients dropped out)	Implants	Implant length (System)	Implant diameter	Crown-to-implant ratio	Bone graft	Arch	Follow-up	Outcomes Short implants	Outcomes Standard implants
Guljé et al. (2014)	RCT	41 (1)	Short 21 Standard 19	Short 6.0 mm Standard 11.0 mm (OsseoSpeed 4.0S ASTRA TECH - Dentsply	Short 4.0 mm Standard 4.0 mm	Short - not reported Standard - not reported	Standard implants with maxillary sinus floor augmentation	Maxilla	1 year	Survival rate: 100% Lost implants: 0 MBL: 0.1 mm (SD 0.2) Prosthetic failures: 0 Surgical complications : 0	Survival rate: 100% Lost implants: 0 MBL: 0.1 mm (SD 0.3) Prosthetic failures: 0 Surgical complications : 0
Mendonza-Azpur et al. (2016)	CCT	82 (0)	Short 41 Standard 41	Short 5.5 and 7.0 mm Standard 10 and 12 mm (Superline - Dentium)	Short - not reported Standard - not reported	Short - not reported Standard - not reported	Without graft	Maxilla and mandible	1 year	Survival rate: 100% Lost implants: 0 MBL: 0.44 mm (SD 0.53) Prosthetic failures: 0 Surgical complications : 0	Survival rate: 100% Lost implants: 0 MBL: 0.22 mm (SD 0.35) Prosthetic failures: 0 Surgical complications : 0
Pohl et al. (2017)	RCT	101 (5)	Short 61 Standard 68	Short 6 mm Standard 11, 13 and 15 mm (OsseoSpeed 4.0S ASTRA TECH - Dentsply)	Short 4.0 mm Standard 4.0 mm	Short - 1.86 Standard - 0.99	Standard implants with maxillary sinus floor augmentation	Maxilla	3 years	Survival rate: 100% Lost implants: 0 MBL: 0.44 mm (SD 0.56) Prosthetic failures: 8 loosenings of abutment screw; 2 decementations of crown Surgical complications : 0	Survival rate: 100% Lost implants: 0 MBL: 0.43 mm (SD 0.58) Prosthetic failures: 2 loosenings of abutment screw; 1 decementations of crown Surgical complications : 1 buccal fistula ; 1 pronounced hematoma
Rossi et al. (2016)	RCT	45 (0)	Short 30 Standard 30	Short 6.0 mm Standard 10.0 mm (SLA® Straumann)	Short 4.1 mm Standard 4.1 mm	Short - 1.49 Standard - 0.95	Without graft	Maxilla and mandible	5 years	Survival rate: 86.7% Lost implants: 4 (3 maxilla, 1 mandible) MBL: 0.52 mm (SD 0.52) Prosthetic failures: 0 Surgical complications : 0	Survival rate: 96.7% Lost implants: 1 (maxilla) MBL: 0.54 mm (SD 0.56) Prosthetic failures: 0 Surgical complications : 0

RCT, randomized clinical trial; CCT, controlled clinical trial; MBL, marginal bone loss; SD, standard deviation.

Quality assessment

The quality assessment of the included studies is presented in table 3 and figure 2. In the item “random sequence generation and allocation concealment”, one study was classified as having a high risk of bias because it was not randomized. For “blinding of outcome assessment”, “incomplete outcome data” and “selective reporting”, the four studies presented low risk. When a radiographic evaluation is needed to assess bone loss, it is possible to identify the group to which the implant belongs, preventing the “blinding of outcome assessment”. However, as MBL was not the primary outcome of this systematic review, the four studies were considered as low risk. All the studies included in the qualitative analysis obtained a high risk of bias in “blinding of participants and personnel”, because the operator always knows the group to which the patient belong at the time of implant placement to perform an adequate technique. For other bias, the follow-up time was evaluated, being considered low risk for the study with 5 years of follow-up, and high risk for the other studies with 1 and 3 years of follow-up.

Table 3. Risk of bias assessment of the included studies.

	Guljé et al. (2014)	Mendoza-Azpur et al. (2016)	Pohl et al. (2017)	Rossi et al. (2016)
Randon sequence generation	LOW RISK - A block randomization sequence was used.	HIGH RISK - not randomized.	LOW RISK - A block randomization sequence was used.	LOW RISK - A block randomization sequence was used.
Allocation concealment	LOW RISK - The Randomization was performed at the day of surgery, using a sealed envelope containing the type of treatment.	HIGH RISK - not randomized.	LOW RISK -The Randomization was performed at the day of surgery, using a sealed envelope containing the type of treatment.	LOW RISK - The Randomization was performed at the day of surgery, using a sealed envelope containing the type of treatment.
Blinding of participants and personel	HIGH RISK - The blinding of surgeons is impossible to perform. The blinding of participants was attempted.	HIGH RISK - The blinding of surgeons is impossible to perform. The blinding of participants was attempted.	HIGH RISK - The blinding of surgeons is impossible to perform. The blinding of participants was attempted.	HIGH RISK - The blinding of surgeons is impossible to perform. The blinding of participants was attempted.
Blinding of outcomes assessment	LOW RISK - Clinical evaluation of the outcome was performed by an independent dentist without knowledge of the group allocation.	LOW RISK - Clinical evaluation of the outcome was performed by an independent dentist without knowledge of the group allocation.	LOW RISK - Clinical evaluation of the outcome was performed by an independent dentist without knowledge of the group allocation.	LOW RISK - Clinical evaluation of the outcome was performed by an independent dentist without knowledge of the group allocation.
Incomplete outcome data	LOW RISK - Losses to follow-up were disclosed.	LOW RISK - There was no loss of patients for final follow-up.	LOW RISK - Losses to follow-up were disclosed.	LOW RISK - Losses to follow-up were disclosed.
selective reporting	LOW RISK - Reported all the intended outcomes described in the methodology of this study.	LOW RISK - Reported all the intended outcomes described in the methodology of this study.	LOW RISK - Reported all the intended outcomes described in the methodology of this study.	LOW RISK - Reported all the intended outcomes described in the methodology of this study.
follow-up time	HIGH RISK - 1-year follow-up.	HIGH RISK - 1-year follow-up.	HIGH RISK - 3-year follow-up.	LOW RISK - 5-year follow-up.

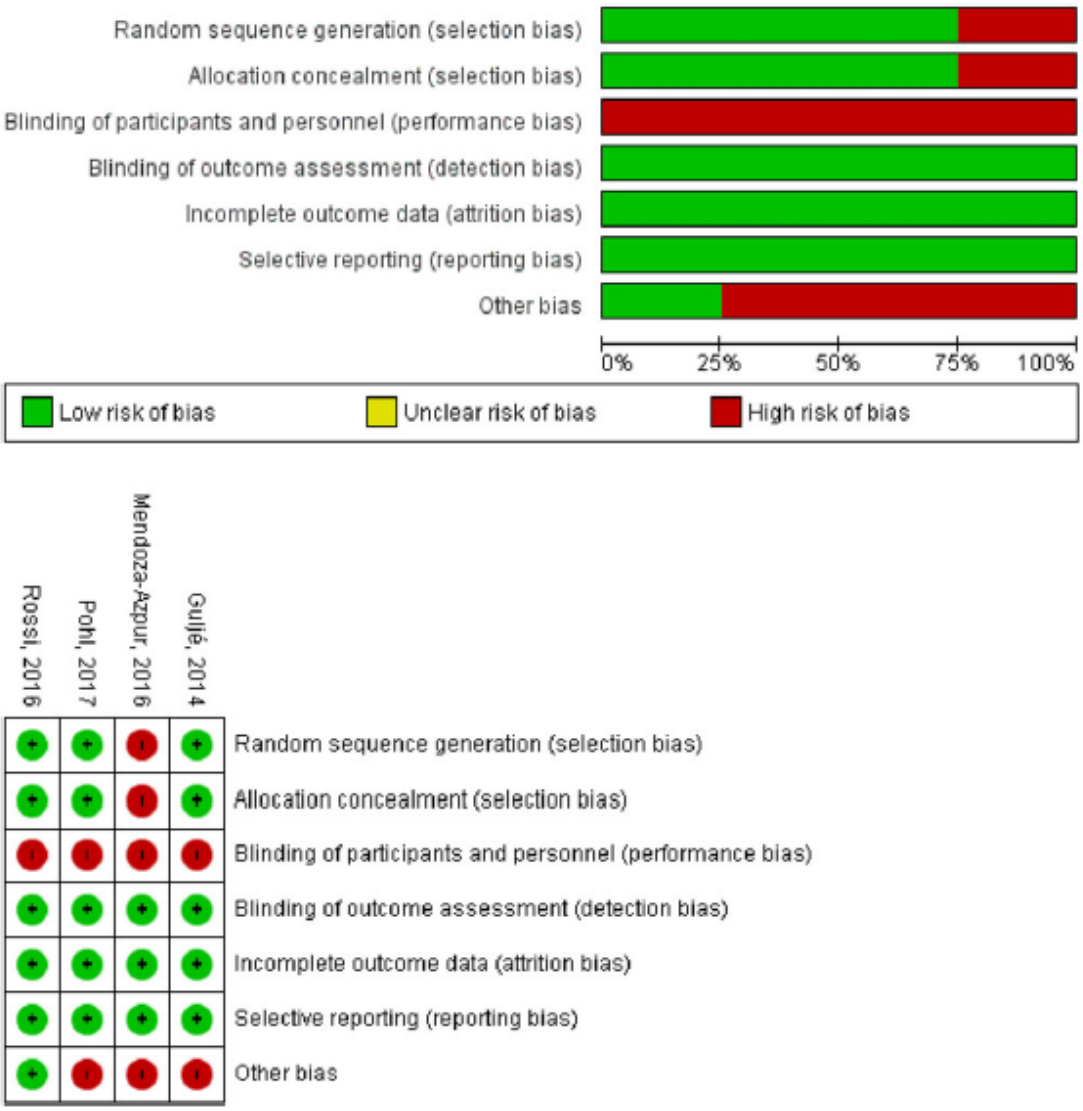

Figure 2. Analysis of the risk of bias.

Results of outcomes in the studies

For success rate of the implants evaluated in posterior single crowns, three studies obtained 100% in both groups tested, within the follow-up period that ranged from 1 to 5 years. The study by Rossi et al.[40] had a success rate of 86.7% for the short implant group and 96.7% for the standard implant group, totaling 4 short implant losses (3 in maxilla and 1 in mandible) and 1 standard implant loss

(maxilla) in a 5-year follow-up period. About these four short implants failures, one was lost before the 1-year follow-up, two failures occurred between the second- and third-year of follow-ups, and one loss during the 4-year follow-up period. The control implant was lost during the first year.[40]

Figure 3 shows the forest plot for the meta-analysis for survival rate for the 1-year follow-up studies. The random-effect model did not show a statistically significant difference between the groups of short implants and standard implants (P = 1.00; RR: 1.00; CI: 0.97-1.03).

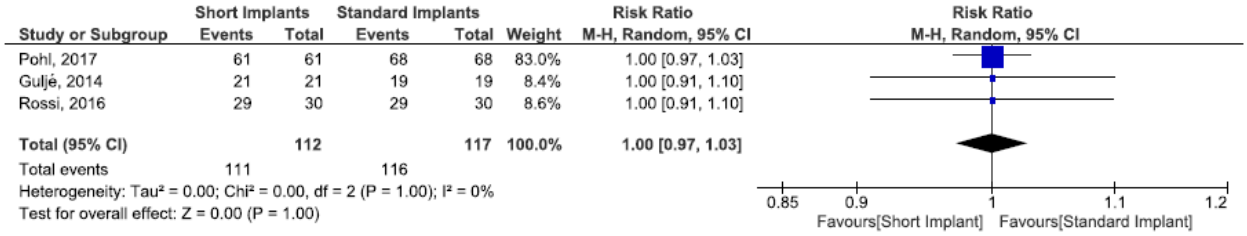

Figure 3. Forest plot of comparison – Survival rate for short implants versus standard implants with 12 months after loading.

The means and standard deviations for MBL, for each group of implants in the four included studies are summarized in table 2. The study by Guljé et al.[70] with a one-year follow-up obtained the lowest value of MBL resulting in 0.1 mm for both groups. Conversely, the study by Rossi et al.[40] with a five-year follow-up presented the highest mean values for MBL, with 0.52 mm for short implants and 0.54 mm for standard implants.

Only the study by Pohl et al.[71] reported the presence of prosthetic failures; there were eight loosenings of abutments screw and two decementations of crowns in the short implants, and two loosenings of abutments and one decementation of crown in standard implants.

The study by Pohl et al.[71] reported a buccal fistula and pronounced hematoma in the group of standard implants with bone graft.

DISCUSSION

The main objective of this systematic review was to compare the survival rate of short implants relative to standard implants in posterior single crowns. There was no difference in the survival rate between the two groups of implants evaluated in the studies included in this review. Reviews with meta-analysis comparing short implants with standard implants using splinted prosthesis in the posterior region have also not demonstrated difference in the success rate between the two types of implants.[24,72] However, one systematic review[38] that compared short and standard implants in single crowns (without RCTs included) showed a significant difference between the groups of implants regarding implant loss, prosthetic failure and MBL, favoring the standard implants. Despite of this, short implants still show acceptable results and reduced rates of biological and prosthetic failures,[38] which corroborates the results of our study. Therefore, these results may lead us to give more credibility to the use of short implants as a safe option for subsequent unitary rehabilitation treatment in the posterior region.

The meta-analysis of the present study showed that the survival rate of the short implants was similar to the standard implants in posterior single crowns, for the one-year follow-up period. This result is in accordance with previous systematic reviews with meta-analysis that evaluated the success rate of short (≤ 8 mm) and standard implants in grafted regions and in splinted prosthesis for the one-year follow-up period.[19,72] However, the success rate of short implants has

decreased from 98.7% for the one-year follow-up to 93.6% for the 5-year follow-up, even without a significant difference when compared to the success rate of standard implants.[72] Two other systematic reviews that evaluated both short and standard implants compared all the included studies in the same meta-analysis, apart from different follow-up periods.[24,38] One of the reviews that evaluated the two groups of implants when used in single crowns (with no RCTs) presented a short implant failure of 5.9%, for a median 40-month follow-up.[38] Another review compared the two groups of implants in splinted or non-splinted prostheses and showed no significant difference between the groups for the success rate with follow-up between 1 and 12 years.[24] In our opinion, to evaluate the success rate of implants only studies with the same follow-up period should be included in the meta-analysis, because the time in function of the implant can determine different success rates. This trend is observed in the study by Rossi et al.[40] that showed an implant success rate of 96.7% for either short and standard implants groups with a 1-year follow-up in contrast to the values of 86.7% and 96.7% for short and standard implants, respectively, for 5 years of follow-up. These results show the difference in the behavior of the implant in function over the years and the importance of evaluating these implants with a longer follow-up period.

One of the studies included in the present review reported the occurrence of 4 maxillary implants failures (3 were short implants) in the first 5 years of follow-up, from the total of 5 implants lost,[40] showing a high number of losses in this arch. Because the maxilla has a lower bone density than the mandible, it is important to use implants with surface treatment and with the presence of micro threads in the cervical portion,[73] in bone type III and IV. Moreover, the quantitative

analysis of both short and standard implants in posterior maxillary implants with splinted prosthesis demonstrated excellent results for survival rate for both groups of implants, with no significant difference.[18,36] Even systematic reviews without meta-analysis have shown similar success rate of these posterior region implants when used in splinted prosthesis, resulting in about 95% for standard implants when used in grafted regions and 96% for short implants.[35] Despite the excellent success rate of the short and standard implants in maxilla, it is important to emphasize the need to perform more RCTs that compare these two groups of implants with clinical follow-up longer than five years.

Short implants tend to have higher crown-to-implant ratio than standard implants. Laboratory studies show more stress of oblique forces on short implants when the crown-to-implant ratio approaches or exceeds values of 2.0. This may interfere with fatigue of prosthetic abutments and also result in more MBL.[30,74] In the present review, this relationship was not found because in the study by Pohl et al.[71] there was lower bone loss (0.44 mm) and higher crown-to-implant ratio (1.86) compared to the study by Rossi et al.[40] which presented more MBL (0.54 mm) with a crown-to-implant ratio of 1.49 for short implants. Recent studies have shown that there is no relationship between the highest crown-to-implant ratio and the highest MBL.[20,75,76] Studies that evaluated short and standard implants in splinted prosthesis with a 5-year follow-up time presented mean MBL in short implants ranging from 0.41 to 2.97 mm compared to the mean MBL for standard implants, which ranged from 0.71 to 3.01 mm.[77–79] Even the short implant having a higher crown-to-implant ratio, it did not present more MBL. Although the concept of increased mechanical risk due to unfavorable crown-to-implant ratio is still to be

verified, it should be emphasized that for compensate for the short length the most of the short implants are designed with wide diameter, so as to have an effective overall surface available for the osseointegration. The long-term stability of short implants is dependent of high bone-implant contact, with the maintenance of maximum bone anchorage and minimal MBL. Our review presents a limitation regarding this evaluation because only two studies[40,71] reported information about crown-to-implant ratio. Thus, we reemphasize the need of more clinical studies with single crowns in short implants with longer follow-up periods to evaluate the behavior of MBL.

The surface treatment of implants, besides providing roughness to increase the surface of contact between implant and bone, provides attraction and adhesion of osteoblasts to accelerate the process of bone healing around the implant, favoring osseointegration and thus allowing greater stability and longevity of the implant.[80,81] The four studies included in this review presented excellent surface treatments that favored rapid bone healing and surface increase by their developed porosity. Two of the four included studies used implants with surface with TiO_2 blasting.[70,71] High performance for implants with this surface treatment has been reported with success rate between 95-100%.[82–85] The other two studies included in the present review used SLA surface implants, treated with sandblasting and acid etching, with excellent results of both survival rate and MBL.[86–88] The two types of surface treatment used in the included studies provided excellent bone-to-implant contact, contributing to the longevity of implant stability on function,[89] as well as collaborating for reduced values of MBL.

Standard implants with abutments in regular external hexagon connections are well established and have been successfully used since the beginning of implantology because of the strong attachment of the implant to the prosthesis and acceptable MBL.[2,47,55] Conversely, regular external hexagon connection implants tend to have more MBL (1.17 ± 0.44 mm) than implants with a switching platform (0.17 ± 0.54 mm) where the abutment diameter is smaller than the implant diameter.[90] Laboratory studies have shown higher stress in the coronal part of the implant and on its abutment, with consequent more fatigue when using implants with external hexagon with switching platform than implants with regular external hexagon, but with no difference between regular internal hexagon connections implants and internal hexagon connections implants with switching platform.[91,92] In this present review, prosthetic failure was only reported in the study by Pohl et al.[71] This good result may be related to the fact that all included studies used implants with internal connection and switching platform: the study by Rossi et al.[40] used implants with internal octagon connection and the other three studies[39,70,71] used implants with internal hexagon connections.

The use of prosthetic restorations with standard implants in patients with low bone height can be performed with previous surgeries of bone grafts, with a success rate of more than 95%.[35,93] The gold standard for alveolar ridge reconstructions to increase osseous thickness and height for subsequent implant rehabilitation has been autogenous bone.[9] Although there are excellent results in cases of prior autogenous graft, this procedure increases the cost of treatment, because of the presence of other specialists when there is a need for removal of extraoral graft, increases the time of treatment, because of the healing time,

increases the number of surgical procedures, and may still occur the need of secondary surgery for re-grafting in cases of primary graft loss.[4,6,9,36,95] In the present review, there were reports of surgical complications only in the group of standard implants in the grafted area.[71]

Standard implants in grafted areas have shown decreased survival rates in long-term follow-ups.[72] Thus, as the survival rates of the short implants were similar to the standard ones in posterior single crowns for the one-year follow-up period as shown in the present study,[39,40,70,71] and previous surgeries with bone grafts for subsequent standard implants placement increase the risk of complications, the cost and the time of the treatment,[4,9,71] the use of short implants may be a feasible alternative for single crown posterior rehabilitation.

The low number of studies included in this systematic review with short follow-up time, in addition to differences in the outcomes reported in the studies and the absence of assessment of the patients' quality of life and satisfaction are some limitations of this study. Therefore, the development of more clinical studies with longer follow-up periods with short implants compared to standard implants in posterior single crowns should be reinforced for a strong conclusion.

CONCLUSION

In the quantitative analysis, the survival rates of the short implants were similar to the standard implants in posterior single crowns, for the one-year follow-up period. In the qualitative analysis, the short implants presented low marginal bone loss,

prosthetic failure and surgical complications, in addition to a good survival rate, being a predictable treatment for single rehabilitation in posterior tooth loss.

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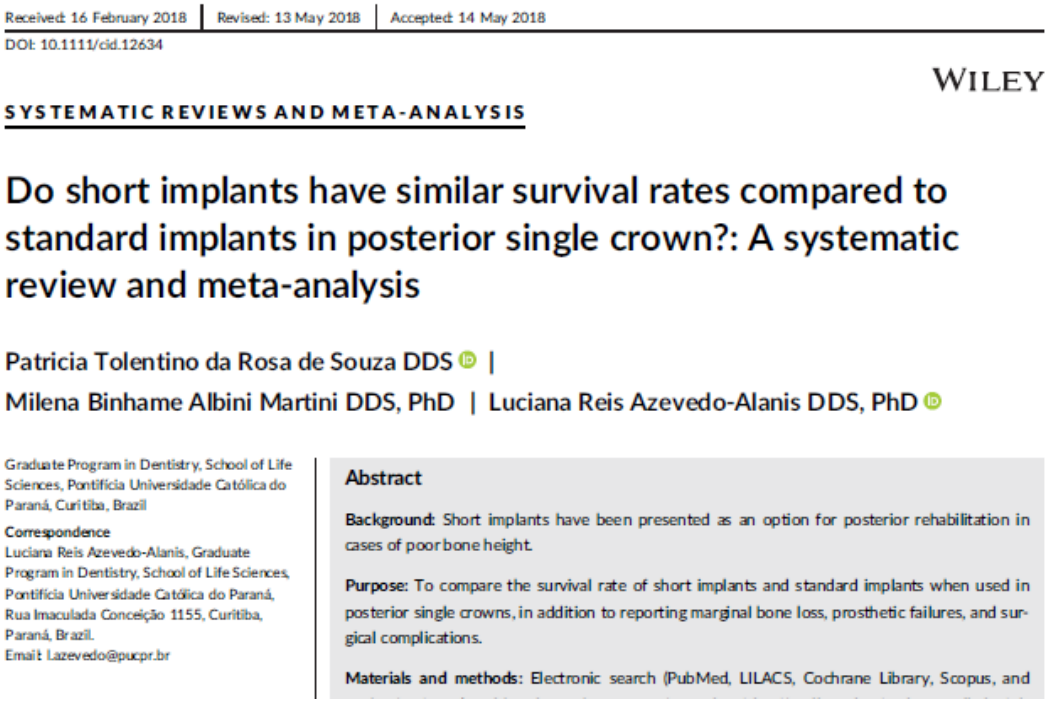
ANNEXS

Annex 1. First page of the article published in Clinical Implant Dentistry and Related Research.



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WILEY

SYSTEMATIC REVIEWS AND META-ANALYSIS

Do short implants have similar survival rates compared to standard implants in posterior single crown?: A systematic review and meta-analysis

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Abstract

Background: Short implants have been presented as an option for posterior rehabilitation in cases of poor bone height.

Purpose: To compare the survival rate of short implants and standard implants when used in posterior single crowns, in addition to reporting marginal bone loss, prosthetic failures, and surgical complications.

Materials and methods: Electronic search (PubMed, LILACS, Cochrane Library, Scopus, and

Annex 2. Carta aos membros da banca examinadora.

Os membros da banca examinadora fizeram sugestões e apontaram algumas correções para a aula de apresentação da dissertação. Todos os comentários foram revistos e os ajustes foram feitos.

Uma discussão sobre busca manual e outros tópicos da metodologia do estudo foi realizada entre candidata e banca examinadora.

Algumas falhas relacionadas com as normas de apresentação do trabalho escrito foram apontadas na qualificação e estão corrigidas nesta versão final.