Short Dental Implants: An Umbrella Review of Current Systematic Reviews and Meta-analysis on Survival Rate of Short Dental Implants

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Introduction: This study aimed to report on systematic reviews assessing the survival/failure rate of short implants. Additionally, marginal bone loss (MBL) and factors affecting survival rates was assessed. **Materials and Methods:** PubMed-Medline, Google Scholar, Latin American and Caribbean Health Sciences Literature (LILACS) and the Cochrane Database of Systematic Reviews were searched up to January 2020. Also reference lists of included systematic reviews were hand-searched. The AMSTAR tool was used for quality assessment. **Results:** 659 studies were reviewed and 37 studies (25 metanalysis) were included. According to the AMSTAR tool, 19 of the 37 reviews were classified as high, 13 as medium and 5 as low quality. The mean score (±SD) was 7.10 (±2.74). The survival rate reported in studies varied from 84% to 100% for follow up periods of 1-5 years (more than 80% of included studies had a minimum follow-up period of 1-5 years), while failure rates ranged from 0% to 37.5% (the same as survival rate range from 62.5% to 100%). Included Systematic reviews reported no significant difference between survival rate/failure of Short implants (SIs) and standard implants with bone augmentation. Two high-quality metanalysis revealed a statistically significant lower survival rate for SIs as well as 2 systematic reviews which found SIs had significantly increased failures. Surface characteristics and implant location showed some association with survival rate. In some studies, SIs experienced lower MBL than standard implants while in others no differences were observed. **Conclusion:** Current knowledge from systematic reviews demonstrated acceptable survival rates for SIs. No significant difference between survival rate/failure of SIs and standard implants with bone augmentation was reported in the majority of studies. **Systematic review registration number**: PROSPERO Number: CRD42020163931.

Keywords: Dental Implant; Dental Implantation; End Osseous; Survival Rate; Systematic Review

Introduction

Dental implant placement is currently considered a treatment option for patients presenting with partial or complete edentulism. Long- term follow-ups have demonstrated predictable survival rates (1-3). Alveolar ridge atrophy may present insufficient bone for conventional implant placement; especially in posterior regions of the maxilla/ mandible (4, 5). A multitude of different surgical interventions have been proposed to treat this problem of atrophic jaws, including (among others) grafting techniques (6), sinus floor elevation (7), inferior alveolar nerve transposition (8), and Guided Bone Regeneration (GBR) (9, 10). There are also graft less alternatives including tilted implants (11), zygomatic implants (12) and short dental implants (SIs) which are more cost-benefit and do not need presurgical interventions prior to implant placement (13).

SIs, are defined as a type of dental implant with an intraosseous length ≤10 mm (13). These implants have been advocated as a treatment option in many clinical situations where the use of conventional implants is limited, due to insufficient bone tissues. An overview of current data suggests that SIs are associated with less complications when compared to longer implants with bone augmentation procedures (3). However, the survival of SIs has been a controversial topic. Some studies reported higher failure rates of SIs when compared with standard implants (14-18). Some previous reviews established that although being a predictable treatment, SIs are associated with a higher risk of failure when compared to longer implant, in longer follow-ups (>3 years) (19).

Some reasons have been postulated to explain the findings; first, shorter implants due to diminished surface area present less bone-implant contact (20). Second, SIs are mostly placed in posterior regions where the survival rate of implants is lower due to numerous factors (21). Moreover, in atrophic jaws in order to have a good occlusion, anatomically correct crowns are desired which results in an unfavorable crown to implant ratio (22, 23). Some authors have reported the survival rates of SIs are comparable to standard conventional implants with grafted bone (16, 24-27).

There is evidence that the crestal part of the fixture is the most load bearing part. Therefore, implant length is not a primary factor for distributing prosthetic load to bone-implant surface (28). Likewise, recent literature has established that adapted surgical preparations and textured-surface modified implant designs have performed successfully in compensating adverse effects of decreased length (utilizing their micro-structured surface) (29) due to the higher bone-to-implant contact (30, 31). Clinicians are required to make decisions on the most suitable choice to treat atrophic jaws. To date, several systematic reviews and metanalysis focused on the survival rate of SIs have been published. Their survival rate has been compared to conventional implants with bone augmentation. However, an overall synthesis and appraisal of these reviews have not been performed so far. The high number of reviews as well as contradictory evidence warrants the need for an overview to bring all accessible data together. This will hopefully yield a conclusion about the survival rate of SIs in short/long follow-ups when compared to standard implants. This umbrella review has been conducted to collect all systematic reviews and their findings to date on the topic. The secondary aim was to provide data on associated factors affecting SIs survival rates and their marginal bone loss.

Materials and Methods

Protocol and registration

The PRISMA guidelines were followed while conducting this study. A publicly available search protocol was submitted to PROSPERO (International prospective register of systematic reviews) (http://www.crd.york.ac.uk/PROSPERO) with the registration number CRD42020163931. Besides, the reporting of this study was based on the PRISMA checklist (32).

Inclusion criteria

Systematic reviews with/without metanalysis that investigated survival/failure rate of SIs or compared survival/failure rates of SIs versus standard with bone augmentation were considered eligible for inclusion. We considered reviews as systematic reviews if they matched the following description, as proposed by the Cochrane Collaboration's Handbook (33): "It uses explicit, systematic methods that are selected with a view to minimizing bias, thus providing more reliable findings from which conclusions can be drawn and decisions made". We included articles published in English up to January 2020.

Exclusion criteria

Primary or original clinical research, abstracts, animal studies, *in vitro* studies, case reports, case series, letters to the editor and narratives, other types of non-systematic reviews (e.g., critical reviews, overviews, state-of-the-art reviews) were excluded. Studies in which implant survival/failure rate was not reported as the primary outcome or survival/failure rate was not related to SIs were excluded from this study. Duplicated studies that were found on more than one database were excluded from this study. Systematic reviews/ metanalysis with less than 3 included articles were excluded as well. The reasons for excluding articles were also recorded.

Information sources and search strategy

The following electronic databases were searched using Mesh terms and other keywords (up to January 2020): PubMed-Medline, Google Scholar and the Cochrane Database of Systematic Reviews, Latin American and Caribbean Health Sciences Literature (LILACS) and reference lists of included systematic reviews were also hand-searched to identify additional pertinent papers. The following terms were used to search the mentioned databases:

Short dental implants OR Implant length OR dental implants AND osseointegration OR survival rate OR implantology OR success rate OR early survival rate OR late survival rate OR implant failure OR late implant failure OR early implant failure OR implant survival.

We applied Review as a search limit to our keywords.

This search syntax was adapted to the different searched electronic databases:

1) PubMed-Medline:

("Short dental implants"[Title] OR "Implant length"[Title] OR "dental implants"[Title]) AND ("osseointegration"[Title] OR "survival rate"[Title] OR "implantology"[Title] OR "success rate"[Title] OR "early survival rate"[Title] OR "late survival rate"[Title] OR "implant failure"[Title] OR "late implant failure"[Title] OR "early implant failure"[Title] OR "implant survival"[Title])

2) Google Scholar:

Concept 1: "osseointegration" OR "survival rate" OR "implantology" OR "success rate" OR "early survival rate" OR "late survival rate" OR "implant failure" OR "late implant failure" OR "early implant failure" OR "implant survival" "short implant"

Concept 2: "osseointegration" OR "survival rate" OR "implantology" OR "success rate" OR "early survival rate" OR "late survival rate" OR "implant failure" OR "late implant failure" OR "early implant failure" OR "implant survival" "length"

3) Cochrane Database of Systematic Reviews

"dental implant" OR "short implant" OR "implant length" in Title Abstract Keyword AND "survival rate" OR "failure rate" "osseointegration" OR "survival rate" OR "implantology" OR "success rate" OR "early survival rate" OR "late survival rate" OR "implant failure" OR "late implant failure" OR "early implant failure" OR "implant survival" in Title Abstract Keyword

4) LILACS

"dental implant" OR "short implant" OR "implant length" [Title words] and "survival rate" OR "failure rate" "osseointegration" OR "survival rate" OR "implantology" OR "success rate" OR "early survival rate" OR "late survival rate" OR "implant failure" OR "late implant failure" OR "early implant failure" OR "implant survival" [Title words]

EndNote X8 Thomson Reuters, computer software, was used to manage references.

Studies selection

The search for eligible studies was conducted by two reviewers independently to determine proper reports using the inclusion and exclusion criteria. To select the potentially eligible studies, the two reviewers read titles and/or articles. Instances of divergence of opinion were resolved by consulting a third investigator. Those which were initially selected were read fully at least twice.

Data extraction

The following data was collected from the articles by an author based on a predefined checklist worksheet and supervised by the third author for accuracy:

i) Summary of studies characteristics: Authors' name and year of publication, country of origin, Source of funding, conflict of interest, number and type of studies included, number of implants, presence of metanalysis (yes/no), databases searched, Search date, follow up, quality assessment tool, main outcome(s), and main conclusion(s). Pooled estimates of survival/failure rates with their 95% CIs, pooled estimates of complications, associate factors of survival/failure of the implants

ii) Summary of the metanalysis (where applicable): Event, study-specific relative risk estimates (risk ratio, odds ratio, or standardized mean differences) along with the corresponding 95% confidence intervals (CI), *P*-value.

Risk of bias assessment in individual studies: After the final selection of eligible articles, the quality assessment of the included studies was performed by two reviewers independently using the AMSTAR tool (34)). For each systematic review 11 items of AMSTAR were answered using 'yes', 'no' or in some cases 'can't answer'.

Analysis and summary measures

The findings and conclusions from existing reviews were presented in qualitative form including tables to aid in data presentation where appropriate. The variables were registered at the patient level. The odds ratio, the risk ratio, and the mean difference were considered. Only aggregate results with 95% confidence interval were reported. The reviews were categorized as 'high', 'medium' and 'low' quality based on an AMSTAR score (8-11, 4-7 and 0-3 respectively). The whole umbrella review was reported according to the Preferred Reporting Items for Systematic reviews and metanalysis (PRISMA) guidelines (32)).

Results

The PRISMA flow diagram of the selection study process through different stages is shown in Figure1. 661 papers were identified through the initial search. We obtained 618 studies after duplication removal. Subsequently, 539 papers were excluded after reading abstracts and 79 papers remained that their full text were assessed for eligibility, of those 59 potentially eligible articles were left which were submitted to full-text analysis. Of those, 22 were excluded. The reasons for exclusion are shown in Table 1. Finally, 37 articles meeting all the inclusion criteria underwent data extraction. Metanalysis was performed in 25 articles.

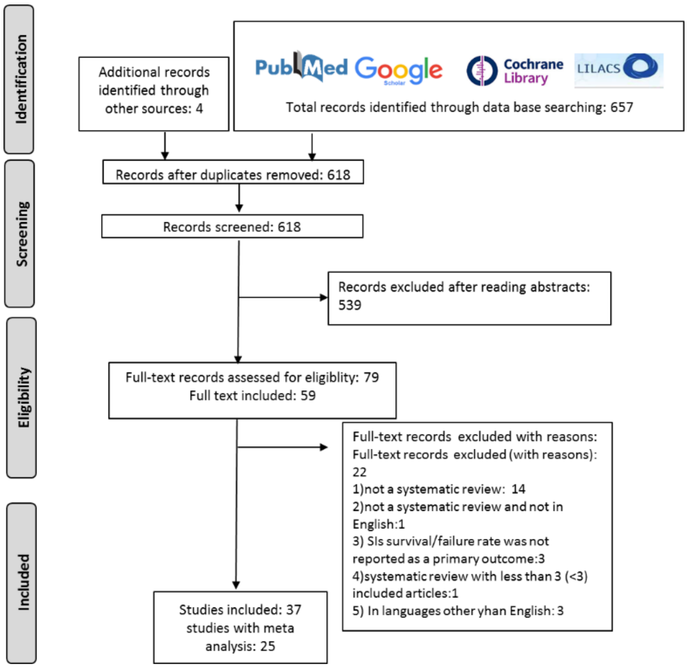

Figure 1. PRISMA flow diagram of The Study Selection Process

Table 1. List of excluded systematic reviews with reasons

Study (first author/year)	Reason for exclusion
Renouard *et al.*, (4)	not a systematic review
Lee *et al.*, (35)	not a systematic review
Nisand *et al.*, 2015 (36)	not a systematic review
Al Hashedi *et al.*, (37)	not a systematic review
Das Neves *et al.*, (38)	not a systematic review
Esfarhood *et al.*, (39)	not a systematic review
Jain *et al.*, (21)	not a systematic review
Tutak *et al.*, (40)	not a systematic review
Edher *et al.*, (41)	not a systematic review
Hagi *et al.*, (42)	not a systematic review
Misch *et al.*, (43)	not a systematic review
Romeo *et al.*, (44)	not a systematic review
Shwarts *et al.*, (45)	not a systematic review
Sirinsavan *et al.*, (46)	not a systematic review
Galvao *et al.*, (47)	not a systematic review and not in English
Al Moraissi *et al.*, (48)	short implant survival/failure rate was not reported as a primary outcome
Monje *et al.*, (49)	short implant survival/failure rate was not reported as a primary outcome
Hingsammer *et al.*, (50)	short implant survival/failure rate was not reported as a primary outcome
Curto *et al.*, (51)	In languages other than English
Nagem *et al.*, (52)	In languages other than English
Gomide *et al.*, (53)	In languages other than English
Blanes *et al.*, (54)	Systematic review with less than 3 articles (< 3)

Studies characteristics

The characteristics of the studies included in this review are depicted in Table 2. All systematic reviews were published between 2009 and 2020. Thirteen reviews didn't specify a distinct risk of bias assessment tool to verify the quality of the studies (24, 55-66). The rest (24 reviews) performed some kind of quality assessment of their included studies.

Thirteen articles mentioned funding sources for the studies (17, 25, 27, 55, 57, 59-61, 64, 67-70), 10 articles reported no support had been received (13, 25, 30, 63, 65, 71-75), and the rest (14 articles) did not report funding status. One article declared conflict of interest (73), 10 articles did not report any information regarding competing interest (16, 26, 55, 58, 59, 61, 62, 68, 76, 77) and the rest (26 articles) reported no conflict of interest.

Table 2. Characteristics of the included systematic review

Author(year), country of origin, funding(Y/N/?) -Conflict of interest(Y/N/?)	Number and Designs of included studies (number of short implants)	Short implant length	SR/SR& M/M	Databases searched (search date)	Follow up	Quality assessment tools	Main findings	Main Conclusion
Annibal *et al.*, (71) (2012), Italy (N)-(N)	2 RCT, 14 Ob;2 prospective, 12 retrospective) (6193 short implants)	<10mm	SR & M	MEDLINE(1966-2010)	1 mo to 14 yrs	Cochrane Collaboration tool (33) and A 14-question checklist (based on previous works(78)	The cumulative survival rate (CSR) was 99.1% (95%98.8-99CI:.4).	High survival rates [99.1% (95%CI: 98.8-99.4)] are reported after a mean follow-up period of 3.2 ± 1.7 yrs. Surgical technique, implant location, and type of edentulism and prosthetic restoration did not affect short-implant survival. Improvements are possible, with rough-surfaced implants preferred.
Fan *et al.*, (25)(2016), China (Y-N)	7 RCT 554 implants (265 short implants)	5-8mm (<8mm)	M	MEDLINE, Embase and Cochrane Library (search date not mentioned)	1-5 years	the Cochrane Handbook of Systematic Review of Interventions (www.cochrane-handbook.org) (33).	There was no significant difference in survival rate between two groups (RR: 1.00; 95% CI: [0.97, 1.03]; p5.96; seven trials, 554 participants)	no difference between the survival rates of short implants (5–8 mm) and long implants (>8 mm)
Gonclaves *et al.*, (56)(2015), Brazil (?-?)	3 RCT, 2 Prospective cohort study, 8 prospective study (1260 short implants)	Less than 10 mm in total length and 8 mm intrabone length	SR& M	Pubmed MEDLINE, Cochrane Library Database, Embase, and Lilacs (2000 2014)	1 to 10 years	a specific evaluation regarding the risk of bias of each selected study was not applied	cumulative implant survival rate data allows meta-analysis revealing a positive effect size (from 0.052 (fixed) to 0.042 (random)	Short implant appears to be a successful treatment option.
Monje *et al.*, (59)(2013), USA (Y-N)	13 prospective clinical trials, (1,955 dental implants, of which 914 were short implants)	<10 mm	M	PubMed and Medline (1997 to 2011)	12-168 months	a specific evaluation regarding the risk of bias of each selected study was not applied	Short dental implants had an estimated survival rate of 88.1% at 168 months, when standard dental implants had a similar estimated survival rate of 86.7% (*P = 0.254*). The peak failure rate of short dental implants occurred at an earlier time point compared with standard dental implants	In the long term, implants of <10 mm are as predictable as longer implants. However, they fail at an earlier stage compared with standard implants.

Uehara *et al.*, (69)(2018), Brazil-Australia(Y-N)	7 RCT (458 short dental implants)	(≤7mm)	M	up to May 2017	at least one year of follow-up (not defined specific ally)	Risk of bias was performed following the recommendatio ns for systematic reviews of interventions of the Cochrane collaboration (33)	The Risk difference between the short implant group and the control group was -0.02 (95% CI: -0.04 to 0.00), I2=0 and Chi2=3.14, indicating a favorable survival rate for short implant, but with no statistical significance (*p=0.09*).	Placement of short dental implants was found to be a predictable alternative for the rehabilitation of atrophic posterior regions, avoiding all the disadvantages intrinsic to bone augmentation procedures
Neldam *et al.*, (61)(2010), Denmark (Y-?)	27(15prospectiv e nonrandomized , noncontrolled clinical trials, 11 retrospective nonrandomized , noncontrolled clinical trials, and one review)	≤8 mm	SR	Medline (1992 to 2009)	2 month to 14 years (lack of consist ency in the follow-up periods and recall time in the differe nt studies)	a specific evaluation regarding the risk of bias of each selected study was not applied	Failures varied between 0 and 14.5%, 0 and 37.5% and 0 and 22.9% of the 6-, 7-, and 8-mm-long implants, respectively.	Short implant length was not related to failure rates
Corbella *et al.*, (65)(2013), Italy(N-N)	44 RCTs (901 short implants)	less than 10 mm long	SR	Medline database(19 70-2013)	1-10 years follow up for short implan ts	a specific evaluation regarding the risk of bias of each selected study was not applied	The implant survival rate of short dental implants varied from 86.5% to 98.2% with up to 5 years follow-up.	The treatment choice should be based on a careful evaluation of the individual case, in particular on the available residual bone. The use of short implants is promising but needs further investigation to be considered as effective as the other techniques in the long term
Menchero *et al.*, (58)(2011), Spain (?-?)	16 Longitudinal studies, 7,392 short implants(2807 machined surface,4455 rough surface(the total number of patients is unknown)	10 mm or less	M	PubMed (2000 to 2010)	1-16 years follow up	a specific evaluation regarding the risk of bias of each selected study was not applied	The majority of the studies obtain a cumulative survival rate (CSR) similar to that of longer implants (92.5% - 98.42% for machined and rough-surface implants, respectively). The studies that record lower cumula-tive success rates (CSR) are later studies that analyze implants with a machined surface.	rehabilitations with short implants are a reliable treatment

Nisand *et al.*, (26) (2015), France, Sweden, UK (?-?)	four RCT's 163 short implants, (135 patients)	≤8 mm	SR	PubMed (1976 to 2015)	1 to 5 years	Cochrane Collaboration's tool for assessing risk of bias in randomized trials(33)	Survival rates of implants placed in vertically augmented bone and short implants was 95.09% and 96.24%, respectively	-similar implant and prosthetic survival rates between short implants and longer implants placed in vertically augmented bone - vertical ridge augmentation by means of interpositional bone substitute blocks seems to be associated with an increased treatment time and cost together with an increased rate of complications
Palacious *et al.*, (67), (2017) Spain ,Portugal, USA (Y-N)	8 RCTs (458 short implants,488 regular implants)	length < 10 mm	SR	PubMed, LILACS, The cochrane library (till June 2016)	12 to 60 month	Cochrane Collaboration's tool for assessing risk of bias in randomized trials(33)	From a total of 458 short implants, 15 failed (mean survival rates = 96.7%), While from 488 regular implants, 13 failed (mean survival rates = 97.3%).	no difference between both techniques in the treatment of atrophic arches
Mezzomo *et al.*, (17),(2013), Brazil (Y-N)	21 articles (16 prospective parallel-designed studies, 10 cohorts and 6 case series (762 short implants)	<10 mm	M	PubMed, Medline, Web of Science, Cochrane Library, Proquest-Dissertatio ns and Thesis, Lilacs, Ebsco-Dentistry and Oral Sciences Source, Scirus, Embase, Scopus , Journal Ovid	12-120 month	according to the methodology applied, confounding factors, ethical aspects, funding, conflict of interest, unit of analysis for statistics (patient or implant) and external validity(30).	The mean Failure Proportion was 5.9% (95% CI: 3.7–9.2%)	Single crowns supported by short implants in the posterior region are a predictable treatment option with reduced failure rates
Monje *et al.*, (60), (2013) USA, Spain, Singapore (Y-N)	13 papers (1,955 total dental implants 914 short implants)	<10 mm	M	PubMed and Medline (1997 to 2011)	18-108 month	a specific evaluation regarding the risk of bias of each selected study was not applied	Short dental implants had an estimated survival rate of 88.1% at 168 months, when standard dental implants had a similar estimated survival rate of 86.7% (*P = 0.254*)	in the long term, implants of <10 mm are as predictable as longer implants. However, they fail at an earlier stage compared with standard implants.
Pommer *et al.*, (74) (2011), Austria (N-N)	54 observational paper (19,083 implants)	<10 mm	M	MEDLINE, EMBASE,	first year of prosthe	Newcastle Ottawa Scale (NOS)(78)	A significant impact of implant length could be substantiated for short	In areas of reduced alveolar bone height the use of short dental

		minimum length: 7 mm		and CENTRAL 1998 to 2008	tic loading		machined implants in the anterior [odds ratio (OR) 5.4] and posterior maxilla (OR 3.4), while short rough-surfaced implants demonstrated increased failure rates in the anterior maxillary sites.	implants may reduce the need for invasive bone augmentation procedures
Sirinvasan *et al.*, (63)(2014) (N-N)	12 papers (690 Straumann_ 6-mm-short implants)	6 mm	SR & M	PubMed 1987 to 2011	1–8 years	a specific evaluation regarding the risk of bias of each selected study was not applied	The pooled early CSR% calculated in this meta-analysis was 93.7%, whereas the overall survival rates in the maxilla and mandible were 94.7% and 98.6% respectively. Implant failures observed were predominantly early failures (76%).	Provides robust evidence that micro-rough 6-mm-short dental implants are a predictable treatment option, providing favorable survival rates. The failures encountered with 6-mm-short implants were predominantly early and their survival in the mandible was slightly superior.
Telleman *et al.*, (30)(2011), The Netherlands (N-N)	29 papers (28 prospective cohort and one randomized-controlled trial (RCT) 2611 short implants	<10 mm (lengths 5–9.5 mm)	SR	MEDLINE and EMBASE 1980–2009	3.7 years (range 1.6–8.1 years)	using the forms "quality assessment of a cohort study" and "quality assessment of a randomized clinical trial" developed by the Dutch Cochrane Centre, a centre of the Cochrane Collaboration(32)	An increase in implant length was associated with an increase in implant survival (from 93.1% to 98.6%).	There is fair evidence that short implants can be placed successfully in the partially edentulous patient, although with a tendency towards an increasing survival rate per implant length
Vazouras *et al.*, (19)(2019), USA (N-N)	20 studies (11 RCTs and 9 prospective) 1238 short implants in 747 patients	≤6mm	M	MEDLINE (PubMed) 1990 to 2018	1-4.75 years	the Cochrane Collaboration's tool for assessing risk of bias in randomized trials and the Newcastle-Ottawa scale assessment tool for prospective studies(78).	The overall (early and late) mean percentage of short implant failure was 4%. SI with up to 1 year follow-up presented failure rate of 2%, while SI followed-up for > 3 years showed a failure rate of 10%.	SI in function for more than 3 years presented higher failure rates compared to SI in function for less than 3 years.
Altib *et al.*, (13) (2019), Indonasia (N-N)	13 RCTs	≤ 8 mm	SR & M	Pubmed, Cochrane Central of Registered Controlled Trials	1-10 years	the Cochrane Collaboration tool for assessing the risk of bias(78).	The meta-analysis showed no significant differences regarding the implant failure rate at 1 year (I2 = 67%,	Short dental implants seem to be.an effective alternative treatment for the atrophic posterior ridge. there are no statistically

				(CENTRAL) Up to 2018			*P* = .13; risk difference [RD]: −0.05, 95% confidence interval [CI]: −0.11, 0.01), at 3 years (I2 = 58%, *P* = .17; RD: −0.04, 95% CI: −0.01, 0.02), and at 5 to 10 years (I2 = 0%, *P* = .47; RD: −0.05, 95% CI: −0.19, 0.09)	significant differences in regard to implant failure
Bitaraf *et al.,* (76) (2019), Iran (?-?)	23 RCT 2228 dental implants (number of short implants not mentioned)	4-8 mm	SR & M	PubMed, Web of Science, EMBASE, Scopus, the Cochrane Central Register of Controlled Trials, and ClinicalTrials.gov Up to 2017	1-5 years	the modified Cochrane Collaboration tool for risk of bias(32)	There were no significant differences in implant failure (RR: 0.75 [0.44,1.27]) for Short implants compared to the Standard implants in both jaws up to 1-year follow-up	Short implants and Standard implants showed the comparable outcomes
Kotsovilos *et al.,* (79) (2009), Greece (?-N)	37 cohorts (number of short implants not mentioned)	<8 to ≤10 mm	SR & M	PubMed and the Cochrane Central Register of Controlled Trials (CENTRAL) 1994-2007	12-107.8 months	using certain criteria proposed in the dental literature (80-82)	Meta-analyses revealed no statistically significant difference in survival between short and conventional rough-surface implants placed in totally/ partially edentulous patients.	the placement of short rough-surface implants is not a less efficacious treatment modality compared to the placement of conventional rough-surface implants for the replacement of missing teeth in either totally or partially edentulous patients
Lee *et al.,* (83) (2014), USA (?-N)	4 RCT 539 dental implants (265 short implants)	5 to 8 mm	SR & M	MEDLINE (PubMed) and EMBASE 1990-2013	1 to 5 years (Mean: 2.1 years)	the risk of bias was assessed based on the Cochrane Collaboration tool(33)	The 1-year and 5-year cumulative survival rates (CSR) were 98.7% (95% confidence interval [CI], 97.8% to 99.5%) and 93.6% (95% CI, 89.8% to 97.5%), respectively, for the short implant group and 98.0% (95% CI, 96.9% to 99.1%) and 90.3% (95% CI, 85.2% to 95.4%), respectively, for the control implant group. The CSRs of the two groups did not demonstrate a statistically significant difference. There were also no statistically significant differences in success rates, failure rates between the two groups	Placement of short dental implants could be a predictable alternative to longer implants to reduce surgical complications and patient morbidity in situations where vertical augmentation procedures are needed.

Lemos *et al.*, (16)(2016), Brazil (?-?)	13 studies, 1269 patients and 2631 dental implants	equal or less than 8 mm	SR & M	PubMed/Medline, Embase and The Cochrane Library Up to 2015	4 month to 5 years	according to the Jadad scale(84)	The results showed that there was no significant difference of implants survival (*P* = .24; RR:1.35; CI: 0.82–2.22)	Although being a predictable treatment for atrshort implants with length less than 8 mm (4–7 mm) should be used with caution because they present greater risks to failures compared to standard implants
Ravida *et al.*, (18) (2019), USA (Y-N)	18 RCT 1612 implants (793 extra-short and 820 long implants)	≤6mm (compared to long implants ≥10 mm)	M	PUBMED (MEDLINE) and EMBASE	1-5 years	the Cochrane Risk of Bias Tool for Randomized Controlled Trials(33)	No statistically significant difference in the survival rate being observed at 1 and 3 years (*p>0.05*)	Placement of extra-short implants (≤6 mm) presented as an equivalent option in the treatment of patients with an atrophic posterior arch up to 3 years follow-up. However, the longterm effectiveness of extra-short dental implants remains to be further studied
Cruz *et al.*, (85)(2018), Brazil (?-N)	11 RCT 420 patients 911 dental implants	(≤ 8.5 mm)	SR & M	PubMed/MEDLINE, Embase, LILACS, and Cochrane Library databases Up to 2018	9-36 months	The Cochrane Collaboration’s tool for assessing the risk of bias in randomized trials(33)	No significant difference was observed in the survival rate [*p = 0.86*; risk ratio (RR): 1.08; 95% confidence interval (CI): 0.46–2.52]	Short implant placement is an effective alternative because of fewer biological complications and similar survival
Sierra-Sanchez *et al.*, (66) (2016), Spain (?-N)	37 RCT and PCT 9792 implants	< 10 mm	SR	Medline-PubMed 2004-2014	1-14 years	a specific evaluation regarding the risk of bias of each selected study was not applied	The implant survival rates ranged from 83.3% to 100% reported in the included studies.	short implants are seen to offer clinical results in terms of survival, similar to those of longer implants
Yan *et al.*, (70) (2019), China UK (Y-N)	7 RCT 310 participants	≤6 mm	SR & M	PubMed, Embase and the Cochrane CENTRAL	1-3 years	the Cochrane risk of bias assessment tool for RCTs(33)	No significant difference in survival rate was found for 1–3 years follow-up (RR 1.01, 95% CI 0.97 to 1.04, *p=0.74*, I2=0%, moderate-quality evidence) or for 3 years or longer follow-up (RR 1.00, 95% CI 0.97 to 1.04, *p=0.79*, I2=0%, moderate-quality evidence	For atrophic posterior maxilla, short implants are a promising alternative to sinus floor elevation, with comparable survival rate
Ting *et al.*, (64) (2015), USA (Y-N)	6 prospective studies 237 participants	<10mm	M	PubMed, Web of Science, Cochrane Central	1-8 years	a specific evaluation regarding the risk of bias of each selected	The overall pooled survival rate of the wide implant is 96.3 %. The meta-regression showed that when using a wide implant,	a wide-diameter implant in atrophic jaws where implant length may be limited by the nerve or the sinus, the use of a short

				Register of Controlled Trials, Google Scholar up to 2014		study was not applied	its length doesn't adversely affected its survival (*P > 0.05*).	implant regardless of its surface would not affect its survival
Al Johany *et al.*, (55) (2019) Saudi Arabia (Y-?)	51 articles 3410 short implants	≤ 6.5 mm	SR	Pubmed (MEDLINE), SCOPUS (Elsevier) and SCHOLAR (Google) 1997 to 2018	12 month s post–prosthe tic loading	a specific evaluation regarding the risk of bias of each selected study was not applied	SDI placed in edentulous posterior regions of the maxilla and mandible have survival rates (96.45%) similar to those of conventional-length implants after a follow-up period of 12 months post–prosthetic loading	In lomg term follow ups short implants have survival rates similar to those of conventional-length implant
Esposito *et al.*, (73) (2019), (N-Y)	4 RCTs 135 patients	4- to 8-mm	SR & M	Cochrane Central Register of Controlled Trials (CENTRAL) and MEDLINE 1950-2018	4 month s to 5 years	the Cochrane risk of bias assessment tool for RCTs(33)	There were no differences for patients having prosthesis (RR = 1.46; 95% CI: 0.52 to 4.09; *P* = 0.47; I2 = 0%) or implant (RR = 1.00; 95% CI: 0.31 to 3.21; *P* = 1.00; I2 = 0%) failures between the two interventions, but there were more patients experiencing complications (RR = 4.72; 95% CI: 2.43 to 9.17; *P* < 0.00001; I2 = 0%) and peri-implant marginal bone loss (mean difference = 0.60 mm; 95% CI: 0.36 to 0.83; *P < 0.00001*; I2 = 45%) at longer implants in augmented bone.	Five years after loading, prosthetic and implant failures were similar between the two interventions, but complications and peri-implant marginal bone loss were higher and more severe at longer implants placed in vertically augmented mandibles
Atie *et al.*, (24) (2018), USA (?-N)	5 randomized clinical studies; 16 prospective,; 12 retrospective, and 1 study with both prospective and retrospective data	≤8.5 mm	SR	PubMed, Embase, and Cochrane libraries1992 and 2011	range, 1 to 7 years	a specific evaluation regarding the risk of bias of each selected study was not applied	There is no significant difference in the reported survival of short versus long implants. Failure of 59 of 2,573 short implants at 1 year was recorded, with 71% of them failing before loading. Only 101 short implants were followed for 5 years.	The initial survival rate for short implants for posterior partial edentulism is high and not related to implant surface, design, or width. Short implants may constitute a viable alternative to longer implants, which may often require additional augmentation procedures
Chen *et al.*, (72) (2019) (N-N)	10 RCT	5-8mm	M	MEDLINE (PubMed), Embase and		the Cochrane risk of bias assessment tool for	There were no significant differences in the survival rate (RR: 1.01; 95% CI: [0.99, 1.03]; *P* = *.32*) and	This systematic review showed no difference between the survival rates and complications

				Cochrane Library databases		RCTs(33)	complications (RR: 0.48; 95% CI: [0.20, 1.17]; P = .11) between the two groups.	of short implants (5-8 mm) and long implants (≥10 mm).
Karthikeyan *et al.*, (57) (2012) India (Y-N)	28 studies: 1RCT, 12 prospective studies & 10 retrospective studies 3057 short implants	≤7 mm length	SR	Medline 1991 and 2011	4 month to 10 years	a specific evaluation regarding the risk of bias of each selected study was not applied	The survival rate of short implant was found to be increased from 80% to 90% gradually, with recent articles showing 100%.	When severe atrophy of jaws was encountered, short and wide implants can be placed successfully
Mokcheh *et al.*, (86) (2018), Tunisia (?-N)	15 randomized controlled trials, 1 cohort study and 2 systematic reviews 405 short implats	Less than 10 mm (not mentione d in text, it is accordin g to table)	SR & M	MEDLINE (PubMed), Embase (Elsevier), Researchgat e, ScienceDire ct, Google Scholar and the Cochrane Library Cochrane Central Register of Controlled Trials (CENTRAL). 2007 and 2017	4 month to 3 years	the Cochrane risk of bias assessment tool for RCTs(33)	The results of the study showed a survival rate for short implants ranging from 91.8% to 100%, and from 87.8% to 100% for standard implants associated with sinus lift. The results of the meta-analysis did not show a statistically significant difference in the survival rate of the two procedures over the short, medium and long term.	Short implants are a reliable alternative compared to standard implants associated with sinus lift.
Pommer *et al.*, (62) (2018) Austria (?-?)	82 studies 2929 extra-short implants	extra-short implants < 7.0 mm in length	M	Up to 2017 (1997-2017)	Mean follow up of 3 years	a specific evaluation regarding the risk of bias of each selected study was not applied	Shorter implants between 4.0 mm and 5.4 mm in length showed comparable results to implant lengths of 5.5 mm to 6.5 mm (95.1% vs. 96.4%, *P = 0.121*) Implant lengths of 5.5 mm to 6.5 mm, however, performed significantly better in the mandible compared with the maxilla (*P = 0.010*).	Extra-short implants show satisfactory survival rates after a mean follow-up of 3 years. However, implant lengths < 7 mm in the maxilla and < 5.5 mm in the mandible may increase early failure rates.
Ravida *et al.*, (68) (2019) USA (?-?)	11RCT, 8 Prospective cohort studies 910 short implants	≤ 6 mm	SR	PubMed(Medline), Embase (Ovis), Cochrane Up to 2017	1-5 years	the Cochrane risk of bias assessment tool for RCTs(33)	After 5 years of follow-up, a mean survival rate of 94.1% (90% in the maxilla and 96% in the mandible) and a maximum bone loss of 0.53 mm were demonstrated.	Extra-short implants are a viable treatment alternative in ridges exhibiting atrophy, demonstrating a satisfactory survival rate

								Additionally, splinting extra-short implants is associated with fewer prosthetic complications and lower implant failure rate compared with nonsplinted implants
Sun *et al.*, (77) (2011), China (?-?)	35 articles (16 retospective, 13 prospective, 2 longitudinal, 1 multicenter, 2 observational, 1 clinical tial) 14722 short implants	≤ 10mm	SR	PubMed, Cochrane library 1980-2009	2-14 years	a specific evaluation regarding the risk of bias of each selected study was not applied	The total failure rate of SI was: 4.5% The failure rates of SI with lengths of 6, 7, 7.5, 8, 8.5, 9&10 were (%) 4.1, 5.9, 0, 2.5, 3.2, 0.6 and 6.5 respectively.	No statistical difference between the failure rates od short and standard dental implants. Most failures of short implants were: poor bone quality in Max & machined surface
Tolentino *et al.*, (75) (2018), Brazil (N-N)	4 articles (one CCT and three RCTs)	≤ 8 mm	SR & M	PubMed, LILACS, Cochrane Library, Scopus, and Web of Science	1-5 years	the Cochrane Collaboration's tool that assesses risk of bias in randomized clinical trials(33)	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 survival rate of short implants was similar to the standard ones in posterior single crowns, for the one-year follow-up period
Thoma *et al.*, (27) (2015), Switzerland (Y-N)	8 RCTs	≤8 mm	SR	MEDLINE 1990–2014	Not reported	the Cochrane Collaboration's tool for assessing risk of bias in randomized trials (33)	The survival rate of longer implants amounted to 99.5% (95% CI: 97.6–99.98%) and for shorter implants to 99.0% (95% CI: 96.4–99.8%). For shorter follow-ups (3 studies, 8–9 months), the survival rates of longer implants are 100% (95% CI: 97.1–100%) and for shorter implants 98.2% (95% CI: 93.9–99.7%)	Demonstrated predictably high implant survival rates for short implants and longer implants placed in augmented sinus and their respective reconstructions.

The study design of included papers in these reviews was various ranging from case report to randomized clinical trial (RCT). SIs were defined differently in included articles; the intraosseous length ≤10 mm (17, 30, 56, 58-60, 64-67, 71, 74, 77, 86), ≤8.5 (24, 25)(, ≤8 mm (13, 16, 25-27, 61, 72, 73, 75, 76, 83), ≤7mm (57, 62, 69), ≤6.5 mm (55), ≤6mm (18, 19, 63, 68, 70). All reviews were published in the last 11 years. Metanalysis was conducted in 25 of the 37 studies included. Table 3 shows the results of the metanalysis for the events "implant survival", "implant failure" and "marginal bone loss" reported by the reviews that conducted quantitative analysis comparing the results between SIs group and conventional implants with bone graft.

Table 3. Results of the Metanalyses for the events "implant survival", "implant failure" and "marginal bone loss" reported by the reviews that conducted quantitative analysis comparing the results between SIs group and conventional implants with bone graft (whenever applicable)

Study	Event	*P-value*	Relative risk estimates	95% CI	Significant Statistical Difference
Fan *et al.*, (25)	Survival rate	*P=0.96*	RR: 1.00	[0.97, 1.03]	No
Uehera *et al.*, (69)	Survival rate	*P=0.09*	RD: -0.02	[-0.04 to 0.00]	No
Palacious *et al.*, (67)	Survival rate	*P = 0.45*	Relative risk: 1.34	[0.63; 2.87]	No
Lemos *et al.*, (16)	Survival rate	*P = 0.24*	RR:1.35	[0.82–2.22]	No
Chen *et al.*, (72)	Survival rate	*P =0.32*	RR: 1.01	[0.99, 1.03]	No
Tolentino *et al.*, (75)	Survival rate	*P = 1.00*	RR:1.00	[0.97-1.03]	No
Ravida *et al.*, (18) (1 year follow up)	Survival rate	*P=0.90*	RR= 1.01	[0.99 to 1.02]	No
Ravida *et al.*, (18) (5 year follow up)	Survival rate	*P=0.02*	RR=0.92	[0.86 to 0.99]	Longer implants (control group) had higher survival rate
Cruz *et al.*, (85)	Survival rate	*p = 0.86*	RR: 1.08	[0.46–2.52]	No
Yan *et al.*, (70) (1 year follow up)	Survival rate	*P=0.74*	RR 1.01	[0.97 to 1.04]	No
Thoma *et al.*,					
Pommer *et al.*, (74)	Failure rate	*p<0.05*	OR = 1.1	[0.6-2.1]	SIs showed significantly higher failure rate
Palacious *et al.*, (67)	Failure rate	*P > 0.05*	RR: 1.34	[0.67–2.87]	No
Altib *et al.*, (13) (1 year)	Failure rate	*P = 0.13*	RD: −0.05	[−0.11, 0.01]	No
Altib *et al.*, (13) (5 to 10 years)	Failure rate	*P = 0.47*	RD: −0.05	[−0.19, 0.09]	No
Bitaraf *et al.*, (76)	Failure rate	*P<0.05*	RR: 0.75	[0.44,1.27]	No
Lee *et al.*, (83)	Failure rate	*P = 0.47*	RR: 0.68	[0.24 to 1.93]	No
Esposito *et al.*, (73)	Failure rate	*P = 1.00*	RR = 1.00	[0.31 to 3.21]	No
Uehera *et al.*, (69)	MBL	*P=0.002*	MD:-0,13	[-0.22 to -0.05]	SIs showed significantly less MBL
Altib *et al.*, (13) (1 year follow up)	MBL	*P = 0.57*	MD: 0.05	[−0.12, 0.21]	No
Bitaraf *et al.*, (76)	MBL	*P = 0.103*	WMD: −0.08 mm	[−0.13 to −0.03]	SIs showed significantly less MBL
Lemos *et al.*, (16)	MBL	*P = 0.06*	MD: -0.20	[-0.41 to 0.00]	No
Cruz *et al.*, (85)	MBL	*p = 0.08*	RR: −0.05	[−0.10 to 0.0]	No
Yan *et al.*, (70) (1-3 years follow up)	MBL	*P=0.001*	MD=−0.13	[−0.21 to 0.05]	SIs showed significantly less MBL
Esposito *et al.*, (73)	MBL	*P < 0.00001*	MD:0.60	[0.36 to 0.83]	SIs showed significantly less MBL
Chen *et al.*, (72)	MBL	*p<0.05*	MD: -0.13	[-0.20, -0.06]	SIs showed significantly less MBL

Abbreviations: NR: not reported MBL: marginal bone loss OR: odds ratio RR: risk ratio MD: mean difference (mm) RD: risk difference SIs: short implants

Quality assessment

The quality of the included reviews is shown in table 4. According to the AMSTAR tool (34) 19 reviews were categorized as of high quality (13, 16-19, 25-27, 56, 67-70, 72, 75, 76, 83, 85, 86) and 13 as medium quality (24, 30, 55, 59, 60, 63-65, 71, 73, 74, 77, 79) .

Table 4. Summary of quality assessment of the systematic reviews included, using AMSTAR tool

Systematic review (First author, year)	AMSTAR* domains											
	1	2	3	4	5	6	7	8	9	10	11	Total score
Annibali *et al.*, 2012 (51)	Y	Y	N	Y	N	Y	Y	N	Y	N	N	5
Fan *et al.*, 2016 (25)	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	9
Gonclaves 2015 (36)	N	Y	Y	Y	Y	Y	N	Y	Y	Y	N	9
Monje *et al.*, 2013 (39)	N	N	Y	N	N	Y	N	N	Y	Y	N	4
Uehara *et al.*, (49)	Y	Y	Y	N	N	Y	Y	Y	Y	Y	N	9
Neldam *et al.*, 2010 (41)	N	N	N	N	Y	N	N	N	Y	N	N	2
Corbella *et al.*, 2013 (45)	N	N	Y	Y	Y	Y	N	N	Y	N	N	5
Menchero *et al.*, 2011 (38)	N	N	N	N	N	Y	N	N	Y	N	N	2
Nisand *et al.*, (26)	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	8
Palacios *et al.*, 2017 (47)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Mezzomo *et al.*, 2013 (17)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Monje *et al.*, 2013 (39)	N	N	Y	Y	N	Y	N	N	Y	Y	N	5
Pommer *et al.*, 2011 (54)	N	N	Y	Y	N	Y	Y	Y	Y	Y	N	7
Sirinvasan *et al.*, 2014 (43)	N	Y	N	Y	N	Y	N	N	Y	Y	N	5
Telleman *et al.*, 2011 (30)	N	Y	Y	N	Y	Y	Y	Y	Y	N	N	7
Vazouras *et al.*, 2019 (19)	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	8
Altib *et al.*, 2019 (13)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Bitaraf *et al.*, 2019 (56)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	11
Kotsovilos *et al.*, 2009 (61)	N	Y	Y	Y	Y	Y	N	N	Y	Y	N	7
Lee *et al.*, 2014 (59)	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	9
Lemos *et al.*, 2016 (16)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Ravida et al 2019 (18)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Cruz *et al.*, 2018 (60)	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	9
Sierra-Sanchez *et al.*, 2016 (46)	N	Y	N	Y	N	Y	N	N	N	N	N	3
Yan *et al.*, 2019 (50)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Ting *et al.*, 2015 (44)	N	Y	Y	Y	N	Y	N	N	N	Y	N	5
Al Johany *et al.*, 2019 (35)	Y	Y	Y	Y	N	Y	N	N	Y	Y	N	7
Esposito *et al.*, 2019 (53)	N	Y	Y	N	Y	Y	Y	Y	Y	N	N	7
Atie *et al.*, 2012 (24)	N	N	Y	Y	N	Y	N	N	Y	Y	N	5
Chen *et al.*, 2019 (52)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Karthikeyan *et al.*, 2012 (37)	N	N	N	Y	N	Y	N	N	N	N	N	2
Mokcheh *et al.*, 2018 (58)	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	9
Pommer *et al.*, 2018 (42)	N	N	N	Y	N	Y	N	Y	N	N	N	3
Ravida *et al.*, 2019 (48)	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	8
Sun *et al.*, 2011 (57)	N	Y	Y	Y	N	N	N	N	Y	N	N	4
Tolentino *et al.*, 2018 (55)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	10
Thoma *et al.*, 2015 (27)	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	8

AMSTAR: a critical appraisal tool for systematic reviews that include randomized or non-randomized studies of healthcare interventions, or both Y: yes (one point), N: no (0 point), NA: not applicable (0 point), CA: can't answer (0 point).
*AMSTAR domains: 1-Was an 'a priori' design provided? (needs to refer arotocl registration/ethics approval to score yes); 2-Was there duplicate selection and data extraction?; 3-Was a comprehensive literature search performed?; 4-Was the status of publication (i.e., grey literature) used as an inclusion criteria?; 5-Was a list of studies (included and excluded) provided?; 6-Were the characteristics of the included studies?; 7-Was the scientific quality of the included studies assessed and documented?; 8-was the scientific quality of the included studies used appropriately in formulating conclusions?; 9-Were the methods used to combine the findings of studies appropriate?; 10-Was the likelihood of publication bias assessed?; 11-Was the conflict of interest included

5 reviews were of low quality (57, 58, 61, 62, 66, 71). The mean score (±SD) was 7.10 (±2.74).
Included articles were considered biased mainly due to the following reasons:

1) Potential sources of support and conflict of interest were not reported for systematic reviews and/or each of the included studies (36 studies). Only one review reported the potential sources of support and conflict of interest for systematic reviews and each of the included studies (17).

2) There was no reference to a protocol registration or ethical approval before the conduct of review in 8 studies. The remaining (19 studies) scored yes for this section.

Survival rate

In this report, the survival rate was defined as the percentage of dental implants that are still present in the mouth for a certain period of time regardless of functionality and complications. The reviewed studies reported promising results when SIs were placed in atrophic jaws. Thirty-two reviews evaluated the survival rate of SIs (alone or compared to longer implants with bone augmentation) in atrophic jaws (16, 18, 24-27, 30, 55-60, 62-75, 77, 79, 83, 85, 86). 11 were systematic reviews and the rest (21 reviews) performed metanalysis. The survival rate reported for SIs ranged from 84% to 100% for follow up periods of 1-5 years. More than 80% of the included studies had a minimum follow-up period of 1-5 years, and approximately 35% had a minimum follow-up period of 1-10 years.

Six studies compared survival rate of SIs vs regular length implants in atrophic posterior regions specifically (16, 24, 55, 72, 75, 83). Three studies focused on SIs placed in atrophic posterior maxilla (65, 66, 69), while 4 reviews concentrated on studies evaluating the difference between the survival rate of SIs and standard implants accompanied by sinus lifting procedures (27, 70, 85, 86). In all studies, the difference in implant length between the test and control group is small except for review by Ravida *et al.,* (18) which provided a more emphasized comparison between test and control group comparing extra-short (≤6 mm) to long dental implants (≥10 mm).

The systematic reviews mostly assessed studies with single/multiple numbers of implants in partial/fully edentulous jaws but in two reviews only SI placed in partial edentulous atrophic ridges were included (24, 30)). Likewise, in 2 studies by Mezzomo *et al.,* (17) and Tolentino *et. al.,* (75) only single crowns were considered.

A review study with a total of 237 participants assessed SIs with wide diameter placed in atrophic jaws specifically within 1-8 year follow- up. The overall pooled survival rate of the wide implant was 96.3 %. The meta-regression showed that when using a wider implant, its length doesn't affect its survival *($P>0.05$)* (64).

Included systematic reviews mainly pointed out a non-significant difference between the survival rate of SIs and longer implants with bone augmentation. Except for two high-quality metanalysis. Recently, in a high-quality study by Ravida *et al.,* (18), the long- term effectiveness of 910 extra-short dental implants (≤ 6 mm) was questioned and extra SIs with a mean survival rate of 94.1%, revealed a statistically significant lower survival rate after 5 years of follow -up (RR=0.92, 95% CI: 0.86 to 0.99).

Likewise, in a high quality metanalysis by Lemos *et al.,* (16), assessing 1269 patients with 2631 dental implants in 4 months to 5 years follow-ups, SIs was found a predictable treatment. There was no significant difference for survival rate of 8 mm implants (*$P = 0.34$*; RR: 0.50; 95% CI: 0.12–2.07) compared with longer implants. Although for SIs equal or less than 8 sub-analyses were performed to compare the different lengths (8 mm or shorter) individually in relation with standard implants (larger than 8 mm). The SIs with length less than 8 mm showed lower survival rates than longer implants (*$P= 0.02$*; RR: 2.05; 95% CI: 1.12–3.74).

In a low-quality metanalysis evidence and data were considered insufficient (58).

Failure rate

Implant failure describes the situation when dental implants fail to integrate (early failure) or integrate solidly but bone loss happens over time (late failure). In this review, failure rate was defined as the percentage of implants that fail to remain in the mouth regardless of functionality and complications for a certain period of time. The failure rate reported for SIs ranged from 0% to 37.5% (the same as survival rate range from 62.5% to 100%) (61). Ten reviews evaluated the failure rate of SIs compared to longer implants with bone augmentation in atrophic jaws (13, 17, 19, 61, 63, 67, 76, 83). All performed metanalysis except for Neldam *et al.,* (61).

Vazouras *et al.,* (19) (high quality) assessed 1238 SIs (≤6mm) in 747 patients and compared early and late mean percentage of SIs failure and stated that SI in function for more than 3 years (95% CI: 0.07 to 0.13, *P<0.01*) presented higher failure rates compared to SI in function for less than 3 years 2% (95% CI: 0.00 to 0.04, *P<0.01*), 2%Z (95% CI: 0.01 to 0.05, *P<0.01*) for 1 year, 1 to 3 years respectively). The overall (early and late) mean percentage of failure for SIs was 4%.

Studies mostly showed no significant differences regarding the implant failure rate between SIs and standard implants (13, 61, 63, 67, 76, 83) except for a few studies. Pommeret *et al.,* (74) stated that shorter implants presented an overall failure rate statistically significantly higher than that for longer implants within the first year of loading (odds ratio [OR] = 1.8; 95 percent confidence interval [CI], 1.3-2.5). Although, when considering only rough-surfaced implants, short (≥ 7 mm, < 10 mm) and long (≥ 10 mm) implants had similarly high success rates after one year of loading. Likewise, Monje *et al.,* (60) found that although having similar failure rates in both groups, failure peak of SIs occurred in earlier times (between 4 and 6 years of function) when compared to standard dental implants (between 6 and 8 years of function). Mezzomo *et al.,* (17) (high quality) stated that implants with length ≤8 mm *(p=0.01)* had an increased failure portion.

Associated factors

Surface characteristics

The association between survival rate and surface characteristics was assessed in some of the reviews. Annibali *et al.,* (71) (medium quality) reported the effectiveness of surface characteristics on cumulative survival rate of SIs ([rough-surfaced, 99.2% (95%CI: 98.9-99.4) vs. machine-surfaced, 94.6% (95%CI: 92.6-96.6)]). Another systematic review established that failures of SIs were mostly in machined surfaced implants (77). In a low-quality review by Menchero *et al.,* (58) the studies that record lower cumulative success rates (CSR) are studies that analyze implants with a machined surface (a cumulative success rate (CSR) was 92.5% - 98.42% for machined and rough-surface implants, respectively).

Although Telleman *et al.,* (30) (medium quality) couldn't find such association. Also, Mezommo *et al.,* (17) (high quality) stated that SIs failure rate was not significantly influenced by surface treatment *(P=0.05)*.

Implant location

Some reviews evaluated the possible association between the survival rate of SIs and implant location. In a study by Srinivasan *et. al.,* (63)) the overall failure rate in the maxilla was calculated at 5.3%, which was significantly higher than for the mandible, which was 1.4%. Telleman *et al.,* (medium quality) (30) reported higher failure rates for SIs placed in the maxilla. The cumulative estimated failure rate of studies performed in the maxilla was 0.010 implants/year, compared with 0.003 found in the studies in the mandible. Moreover, in the medium quality study by Sun *et al.,* (77) most failures of SIs were due to poor bone quality in the maxilla. In contrast, Mezzomo *et al,* (17) (high quality) observed that implants placed in the mandible revealed a failure rate significantly higher than that for implants in the maxilla (*P= 0.0002*). Although in the study by Vazouras *et al.,* (19) The results of this metanalysis demonstrated similar risk of failure of SIs placed in the maxilla compared to the mandible (3% ,95% CI: 0.00-0.06, *P<0.01*) and 3% (95% CI: 0.00-0.06, *P<0.01*), respectively). Lemos *et al.,* (16) (high quality) couldn't observe significant differences for the longer implants when compared with SIs in the maxilla (*P = 0.28*; RR: 1.50; 95% CI: 0.72–3.09), and similarly, no differences observed in the mandible (*P = 0.34*; RR: 1.52; 95% CI: 0.64–3.63). Ravida *et al.,* (18) (high quality) established that the arch (upper or lower arch) had no impact on the risk ratio difference at 1 and 3 year follow-ups *(P>0.05)*. Annibali *et al.,* (medium quality) (71) could not find such association as well.

Other associated factors

Telleman *et al.,* (30) (medium quality) stated that smoking was a source of heterogeneity on the cumulative survival rate of SIs. For studies that included smokers, the failure rate was 0.008 compared with 0.004 found in studies that excluded smokers. Al Johany *et al.,* (55) (medium quality) observed that smaller implant diameter (OR = 1.59, 95% confidence interval [CI] = 1.03–2.43, *P < .05*), screw-retained restorations (OR = 2.11, 95% CI = 1.25–3.57, *P < .01*), and C/I ratio ≥ 2 (Pearson's *R* = –0.694, *P<.01*) significantly affected SIs survival rate.

Marginal bone loss

Non-significant differences in MBL were noted between case (SIs) and control (Standard implant) groups in some reviews (13, 16, 17, 62, 85). In some papers SIs presented smaller marginal bone loss than standard implants. Ravida *et al.,* (18) (high quality) by comparing extra-Short (≤6 mm) with Longer (≥10 mm) Implants noted less marginal bone loss (MBL) for SIs in 1 and 3 years *(P<0.001)*. The results of the random-effects metanalysis of the 10 studies of MBL from implant placement showed significantly greater MBL in the long implant group with a difference in means of -0.16 (CI: -0.23 to -0.10, *P<0.001*) after 1 year follow up. In 3-year results from six studies, significantly higher bone loss with a difference of -0.23 (CI: -0.34 to -0.13, *P<0.001*) was reported. In the medium quality study by Esposito *et al.,* (73) less SIs placed in vertically augmented atrophic mandibles after a follow-up of 5 years in function experienced MBL than longer ones with bone augmentation (mean difference = 0.60 mm; 95% CI: 0.36 to 0.83; *P < 0.00001*; I2 = 45%). In the study by Chen *et al.,* (72) (high quality) SIs placed in atrophic posterior regions had less marginal bone resorption than standard implants as well (mean difference: -0.13; 95% CI: [-0.20, -0.06]; *P<0.05*). Bitaraf *et al.,* (76) (high quality) showed that there was a significant difference, favoring SIs, in MBLs of both jaws up to 1-year follow-up for 6 mm implants compared to standard implants (weighted mean difference: −0.08 mm [CI: −0.13 to −0.03], I2: 45.4%, *P = 0.103*). Palacios *et al.,* (67) (high quality) at 1-year follow-up (post loading) presented significant mean difference in marginal bone loss in SIs (*P=0.002*; Mean Difference: – 0.10 mm [– 0.16; – 0.03] 95% CI). A significant high heterogeneity was found between the two groups though.

Discussion

An umbrella review is an approach to analyze published systematic reviews on a defined topic/question in order to identify the limitations and strengths of systematic reviews. It is also intended to report consistent/contradictory findings when considering whether the independent systematic review arrived at a reliable conclusion (87). Systematic reviews are mostly of high-level quality, but they might have some methodological biases. The acceptance of the results of a single systematic review has risks (34). Therefore, healthcare practitioners are at risk of generating inaccurate conclusions. The ascending number of systematic reviews and meta-analyses published on a topic warrants conducting an overview of current reviews to provide a reference publication that contains the essential information on a specific topic, cause greater clarity, to reduce uncertainty for decision-making, to recognize residual gaps in knowledge and to provide a high level of evidence for guiding clinical practice (88). Previously some reviews have assessed results of a few reviews on SIs (21, 36, 45). To the best of the authors' knowledge, this is the first overview to summarize and perform a critical appraisal of risk of bias. The assessment of systematic reviews /Meta-analysis on the survival rate of SIs placed in atrophic jaws is the focus of this paper.

Our results suggested that systematic reviews mainly pointed out a non-significant difference between survival rate/failure of SIs and longer implants with bone augmentation except for two high-quality metanalysis which revealed a statistically significant lower survival rate for SIs (16, 18) as well as two SRs which found SIs had significantly increased failure rate (17, 74). One systematic review found that having similar failure rates in both groups, failure peak of SIs occurred in earlier times (60).

In earlier clinical choices, regular length implants were preferred as they seemed to have higher survival rates than SIs. SIs were not accepted for routine clinical use and were considered to have lower survival rates as explained by reduced bone to implant contact, lower primary stability and unacceptable crown to implant ratio. Despite reporting several shortcomings, the idea of SIs was pursued since: The reasons for this are i) In many cases with anatomical deficiencies, placement of standard implants was problematic. ii) The bone augmentation procedures were not universally accepted because of complexity and unpredictability. iii)–Placing the longest possible implants was not the preferred treatment choice as it could increase the risk of bone overheating, excessive bone preparation (lowering primary stability) and bone preparation time. This presents the possibility of the risk of inferior alveolar nerve injury and sinus perforation as well.

Recent literature implies that a reduced crown/implant ratio is not a primary factor for the success or failure of SIs. With improvements in surface technology and better implant to abutment connections, SIs can be a reliable choice in atrophic jaws (36, 45).

Based on the current evidence it can be concluded that reduced implant length seems does not significantly reduce the percentage of dental implant survival and can be a viable choice in atrophic ridges where the use of standard implants requires bone augmentation procedures. Although SIs demonstrated adequate survival rates, their reported survival rates were lower than longer implants (16-18). These contradictory results as explained by Renouard *et al.,* (4) was attributed to differences in associated factors (such as primary stability, bone quality, surface characteristics and surgical bone preparation) in various studies. Although additional studies with longer follow-ups (>10 years) are still needed; our included studies did not have long-term follow-ups.

To ensure acceptable success rates, some researchers have reported the minimal bone height for a standard implant in the posterior region to be at least 10 mm (89). In a review by Nisand *et al.,* (36) guidelines for choosing between SIs and other treatment options in both jaws were based on the residual bone height and bone quality. This protocol is applicable where the width of residual ridge permits placement of at least 5 mm diameter implants. In posterior atrophic jaws with 7 mm remaining bone in maxilla/ 8 mm remaining bone in mandible SIs may be indicated. In the posterior maxilla with 5-6 mm available bone the clinical decision is related to bone quality and the presence of risk factors of MBL over time. With available bone height <5mm in maxilla / <8 mm in mandible advanced surgical procedures are recommended to allow dental implant placement. (Table 5).

Table 5. Classification for treatment of atrophic posterior jaw by Nisand *et al.,* (65)

Atrophic ridge height	Treatment options	
Posterior upper jaw	Bone type I, II, III	Bone type IV history of risk factors of MBL
≥6mm	SIs	SIs
5 to ≤6 mm	SIs	Sinus lift
<5 mm	Sinus lift	Sinus lift
Posterior lower jaw	Treatment options for all types of bone	
≥8 mm	SIs	
<8 mm	Bone augmentation procedures	

Although this guideline didn't consider other treatment choices when placing SIs is possible; for instance, tilted implants and zygomatic implants. In recent years the adoption of tilted implants for the rehabilitation of both edentulous upper and lower jaws has been proposed. Tilted implants are an alternative to bone grafting procedures when the use of SIs may be contraindicated due to limited ridge height. It can be a good choice in limited width as well. In sites with a narrower alveolar ridge, the implant might be intentionally placed at a tilted buccolingual angulation (11, 90). For patients with residual bone height/width that does not permit placement of dental implants, zygomatic implants offer alternatives. This clinical option reduces invasive surgeries like bone grafting or sinus-lifting procedures (91).

In 2018 an umbrella review assessing the effects of different interventions for implant prosthetic rehabilitation in partially edentulous patients with atrophic jaws did not provide sufficient robust evidence to specify the best treatment option for partially edentulous patients with the presence of bone atrophy.

However, considering reduced complications of SIs when compared to longer implants with sinus lift or bone augmentation, they suggested that in case of vertical defects, if the SIs can be used, they should be used (3).

Regarding peri-implant MBL, no significant difference between SIs and standard implants was reported. Few studies reported that there were significant differences, favoring SIs, in MBLs of both jaws (18, 67, 72, 73, 76).

This search also reported on the potential associated factors affecting SIs survival rate in included reviews as a secondary aim. In summary, various factors have been assessed to determine associated factors affecting survival rates that may be affected by confounding factors including systematic diseases, gender, age, bone quality, implant diameter (17). In the present report only a few were described in the included systematic reviews (with the two factors "surface characteristics" and "implant location" being the most frequent factors assessed). Further investigations are needed to determine all associated factors affecting the survival rate of SIs. From a clinical aspect, a higher survival rate for SIs might be obtained by using a surgical bone preparation adapted to location and bone type, as well as using a micro-rough surfaced implants (36).

Reporting deficiencies and gaps in knowledge/methodology

By reviewing the current literature of systematic reviews and metanalysis on the survival rate of SIs, we identified several deficiencies. To improve the quality, the following recommendations are proposed on their conduct and reporting: i) Included studies mostly assessed short term follow-ups (1 year to 5 years). Further studies should investigate survival rate for longer follow ups (>10 years). ii) Only 5 reviews out of 37 included reviews assessed SIs with less than 6 mm length. Additional studies should investigate extra SIs. iii) Current literature compared SIs with standard implants placed with advanced bone augmentation procedures while there are new concepts like zygomatic implants and tilted implants that must be considered for comparison in further studies. iv) In almost all included reviews, there was a small difference in the length of SIs and standard implants. Additional studies should provide a more emphasized comparison for implant length between test and control group; v) All the reviews had some level of gaps related to the quality of studies not reporting potential sources of support. Conflicts of interest for included studies were not identified, in addition, not referring to an established protocol before the conduct of review were the most common biases.

Shortcomings and strengths of the current review

The current review is not flawless. We excluded systematic reviews in languages other than English. Therefore, this review had a degree of selection bias. Data extraction was conducted by one reviewer. The duration of follow-ups varied in a wide range from 4 months to 14 years. In the included reviews, SIs were placed in different anatomical places with different bone qualities. These inconsistencies between included studies, further complicated the interpretation within this umbrella review. There was no general consensus on which length defines a SI; this might cause confusion in the current review as we didn't have a specific reference point for length. We relied on the assessments performed by the review authors and did not conduct the assessment of internal validity separately. Due to the high number of primary studies, internal reassessment was time-consuming and beyond the scope of this review. Due to the nature of umbrella reviews, there might be a degree of overgeneralization of results that warrants interpretations to be done cautiously.

This umbrella review was priori registered in the PROSPERO database to avoid potential flaws/bias and to promote transparency. The current review had a robust methodology due to the fact that two reviewers independently conducted searching, study selection and risk of bias assessment. Likewise, a wide range of electronic databases were searched to find pertinent articles without any time frame. The risk of bias assessment was performed by means of the AMSTAR risk of bias assessment tool (34) the quality of included reviews ranged from low to high. The majority of studies were classified as high quality (19 of 38 studies).

Conclusions

Current knowledge from systematic reviews demonstrates acceptable survival rates for SIs. In the majority of included studies, the differences between survival/failure rates of SIs and longer implants (with bone augmentation) were not significant. In clinical presentations that the height and width of residual bone are not suitable for placement of standard implants and are adequate for SIs, the latter group should be considered. This may obviate the need for complicated bone augmentation procedures. It also gives patients who are medically or financially compromised, or unwilling to undergo additional surgical procedures, with a viable treatment option.

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