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REVIEW ARTICLE

WILEY CLINICAL ORAL IMPLANTS RESEARCH

Number of implants placed for complete-arch fixed prostheses: A systematic review and meta-analysis

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Abstract

Objectives: The main purpose of this systematic review was to evaluate outcomes related to the number of implants utilized to support complete-arch fixed prostheses, both for the maxilla and the mandible.

Materials and methods: This review followed the reporting guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). A focused question using the PICO format was developed, questioning whether "In patients with an implant supported fixed complete dental prosthesis, do implant and prosthetic survival outcomes differ between five or more compared to fewer than five supporting implants?". A comprehensive search of the literature was formulated and performed electronically and by hand search. Two independent reviewers selected the papers and tabulated results. Primary outcomes analyzed were implant and prosthesis survival. Implant distribution, loading, and type of retention were observed as secondary outcomes, as they relate to the number of implants. A meta-analysis was performed to compare results for studies by number of implants.

Results: The search strategy identified 1,579 abstracts for initial review. Based on evaluation of the abstracts, 359 articles were identified for full-text evaluation. From these, 93 were selected and included in this review, being nine RCTs, 42 prospective and 42 retrospective. Of the 93 selected studies, 28 reported number of implants for the maxilla, 46 for the mandible, and 19 for both maxilla and mandible. The most reported number of implants for the "fewer than five" group is 4 for the maxilla, and 3 and 4 for the mandible, whereas for the "five or more" implants group, the most reported number of implants was 6 for the maxilla and 5 for the mandible. No significant differences in the primary outcomes analyzed were identified when fewer than five implants per arch were compared with five or more implants per arch ($p > 0.05$), in a follow-up time ranging from 1 to 15 years (median of 8 years).

Conclusions: Evidence from this systematic review and meta-analysis suggests that the use of fewer than five implants per arch, when compared to five or more implants per arch, to support a fixed prosthesis of the completely edentulous maxilla or mandible, present similar survival rates, with no statistical significant difference at a $p < 0.05$ and a confidence interval of 95%.

KEYWORDS
complete, complete fixed prosthesis, dental implants, edentulous, number of implants

1 | INTRODUCTION

The initial concept for clinical utilization of osseointegrated dental implants was developed and proven through the rehabilitation of edentulous patients. The number of implants utilized per arch varied significantly in early publications and was inconsistently reported on. Brånemark's configuration proposed using five implants for the mandible and six for the maxilla to support a complete-arch fixed prosthesis, with all implants distributed anteriorly, placed parallel to each other and splinted together by a passively fitted prosthesis. Implant and prosthesis survival rates were considered satisfactory, exceeding 90% after 10 years (Adell, Eriksson, Lekholm, Brånemark, & Jemt, 1990; Adell, Lekholm, Rockler, & Brånemark, 1981; Brånemark, Svensson, & van Steenberghe, 1995). Other authors reported using as many implants as possible in the maxilla (ranging from 6 to 10), and five to six implants distributed between mental foramen in the mandible, as a standard choice (Zarb & Schmitt, 1990). There have been reports documenting the use of as low as two (Cannizzaro et al., 2012) or three (Brånemark et al., 1999; De Bruyn et al., 2001) implants to support a fixed restoration in the mandible. More recently, suggestions for the use of as many as eight implants in the maxilla and six in the mandible for segmented full-arch restorations have also been proposed (Gallucci et al., 2016).

Biomechanics and more specifically implant distribution is a consideration. Efforts to reduce possible negative outcomes associated with cantilevers, on both the implants and prostheses, have seen an added focus on distribution of implants in addition to number (Lambert, Weber, Susarla, Belser, & Gallucci, 2009; Primo, Mezzari, da Fontoura Frasca, Linderman, & Rivaldo, 2018; Schley & Wolfart, 2011). Early publications (Brånemark et al., 1995; Zarb & Schmitt, 1990) proposed that dental implants be positioned parallel to each other when used to support full-arch prostheses. In the maxilla, where bone may not be available to support satisfactory distribution, grafting techniques can be used to create bone volume capable of supporting not only more implants, but also an improved biomechanical distribution (Schliephake, Neukam, & Wichmann, 1997). Although grafting techniques such as sinus floor augmentations are predictable methods of improving bone volume for long-term implant survival and success (Aghaloo & Moy, 2007; Chiapasco, Casentini, & Zaniboni, 2009), increased treatment time, cost, and morbidity are considerations, and researchers and clinicians seek alternative protocols.

Reducing invasiveness and the costs associated with grafts and a higher number of implants is often a goal that can make implant rehabilitation available to a greater number of edentulous patients. Intentionally tilted or inclined implants have been proposed as an alternative to grafting. These techniques can assist in reducing the length of cantilevers and improve the antero-posterior distribution of implants around an arch (Aparicio, Perales, & Rangert, 2001; Krekmanov, 2000). This approach may also reduce the number of implants required to support a fixed complete-arch prosthesis (Kronström et al., 2003; Maló, Rangert, & Nobre, 2003) and has become a popular clinical solution in recent years.

Lambert et al. (2009) showed that in the maxilla, the antero-posterior distribution of the implants influenced the survival rates. Implant-prosthetic protocols with an adequate anterior–posterior implant distribution resulted in statistically significant improvements in prosthodontic survival rates when compared to those with a more anterior, less well-distributed implant position. However, the same assumption cannot be made for the mandible. In a systematic review, Papaspyridakos, Mokti, et al. (2014) reported that the number of supporting implants and the implant distribution had no influence on the implant survival in the mandible. Of 2,827 implants placed, 2,501 (88.5%) were placed interforaminally. No report was made relative to whether implants included in the evaluation were positioned parallel to each other or with inclination, in order to reduce the cantilever.

A two-stage implant placement procedure was recommended as standard, and long-term follow-up studies have demonstrated high survival rates for complete-arch fixed rehabilitations supported by smooth surface implants, with the majority of reports documenting a number of implants ranging from 6 to 12 in the maxilla (Jemt & Johansson, 2006) and 4 to 8 in the mandible (Balshi, Wolfinger, Stein, & Balshi, 2015). However, immediate loading also demonstrates benefit for patients, associated with reduced overall treatment times. With the evolution and improvement in surgical techniques, implant surfaces and connections, immediate loading protocols have been more frequently used and reported on (Shigehara, Ohba, Nakashima, Takanashi, & Asahina, 2015; Strietzel, Karmon, Lorean, & Fischer, 2011; Weber et al., 2009). Papaspyridakos, Chen, Chuang, and Weber (2014) conducted a systematic review on immediate loading protocols for completely edentulous patients rehabilitated with fixed prosthesis and concluded that when selecting cases carefully, and using implants with a microroughened surface, immediate loading with fixed prostheses in edentulous patients results in similar implant and prosthesis survival and failure rates when compared to early and conventional loading.

Surgical and restorative protocols continue to evolve, with digital impression making, digital surgical and prosthetic planning and computer-aided design and manufacturing allowing for a more precise infrastructure, delivered in a shorter period of time for the patient. More rapid protocols allow for predictable early and immediate patient treatments with growing scientific support (Kapos, Ashy, Gallucci, Weber, & Wismeijer, 2009; Lee & Gallucci, 2013; Maló, Nobre, Borges, Almeida, 2012; Papaspyridakos et al., 2016; Papaspyridakos, Rajput, Kudara, & Weber, 2017).

There are, however, several variables to be considered when discussing the number of implants utilized to support a complete-arch fixed restoration (Ellis & McFadden, 2007; Mericske-Stern, & Worni, 2014; Schley & Wolfart, 2011). These include the soft and hard tissue conditions of the edentulous jaw, distribution of the implants, anatomic risks, aesthetics and facial appearance, choice of material and design of prostheses, type of retention of the prostheses and type and timing of occlusal loading. Recommendations for the number of implants, and the type of complete-arch fixed prosthesis are mostly empirical, and decisions are made as a result of clinical experience, anatomic conditions, patients' preferences and costs. Hence, the number and distribution of implants placed to support a fixed complete-arch restoration, both in the maxilla and in the mandible, remains an interesting and controversial topic. There is an increasing volume of papers describing the use of fewer implants, with varying distribution.

This review therefore focuses only on reported outcomes associated with the number of supporting implants (as the variable) utilized for fixed dental prostheses in the completely edentulous maxilla and mandible.

2 | MATERIALS AND METHODS

This review followed the reporting guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Liberati et al., 2009). The PRISMA 2009 checklist statement consists of a 27-item checklist and a four-phase flow diagram (Figure 1). The checklist provides guidelines for transparent reporting of a systematic review.

2.1 | PICO focused question

A focused question using the PICO (Population, Intervention, Comparison, Outcomes) format was developed, questioning whether "in patients with an implant supported fixed complete dental prosthesis, do implant/prosthetic outcomes differ between five or more compared to fewer than five supporting implants?".

Population was defined as edentulous arch with an implant supported fixed prosthesis; Interventions as fixed prosthesis supported by five or more implants; and comparison as fixed prosthesis supported by fewer than five implants. Primary outcomes measured were implant and restoration survival rates.

2.2 | Data sources and eligibility criteria

A comprehensive search of the literature was performed by a medical librarian (*TWE*) in Ovid MEDLINE, PubMed, EMBASE, and the full Cochrane Library. All searches were updated on March 31, 2018, and all databases were searched from inception. Bibliographies of relevant studies were also reviewed for additional references.

The complete search strategies for each database are reported in Appendix S1 and can be reproduced. Database-specific subject headings and keyword variants for each of the four major concepts—edentulism, dental prostheses, dental implant numbers and survival—were identified and combined.

2.3 | Inclusion and exclusion criteria

Studies were included if they:

1. examined rehabilitation of edentulous patients with complete-arch fixed prosthesis;
2. included at least 10 patients with a minimum follow-up period of 12 months;
3. *clearly* stated the number of implants used for each arch (maxilla or mandible);
4. described the survival rates for the prosthesis and the implants.

Tilted implants and graft cases were considered, as long as they met the previous criteria.

Randomized clinical trials, prospective and retrospective studies were considered, if the above criteria were met.

Results were limited to the English language. Animal and in vitro studies were excluded as well as single case reports. Zygomatic implants and oncologic rehabilitation publications were excluded.

2.4 | Study selection

References were identified through database searching as described in the search methodology. Duplicates were removed, and titles and abstracts were screened independently by two reviewers (WDP and TA), using the specific inclusion and exclusion criteria to accomplish the item generation and item reduction. Kappa agreement of inter-rater reliability was performed. Cohen's κ was run to determine whether there was agreement between the two authors' judgments during the item reduction. For title and abstract review, there was good agreement between the two authors' judgments, $\kappa = 0.46$ (80% agreement rate).

Full text was requested after selection and reviewed for inclusion and exclusion criteria. Two reviewers (WDP and TA) independently selected the studies to be included. During full-text review, any disagreements were resolved through direct communication, until consensus was reached.

2.5 | Data extraction

After reviewing the full paper, data were extracted and tabled in the following order: number of implants per arch, first author, year of publication, study design, total number of implants, total number of arches, position of implants per arch, type of implants (manufacturer), mean follow-up, follow-up range, survival of implants, survival of restorations, type of loading (immediate vs. delayed) and form of retention (screw vs. cemented).

Primary outcomes analyzed were the survival of implants (defined as an implant reported as stable, still fulfilling function as a support for the prosthesis, with no signs of infection), and survival

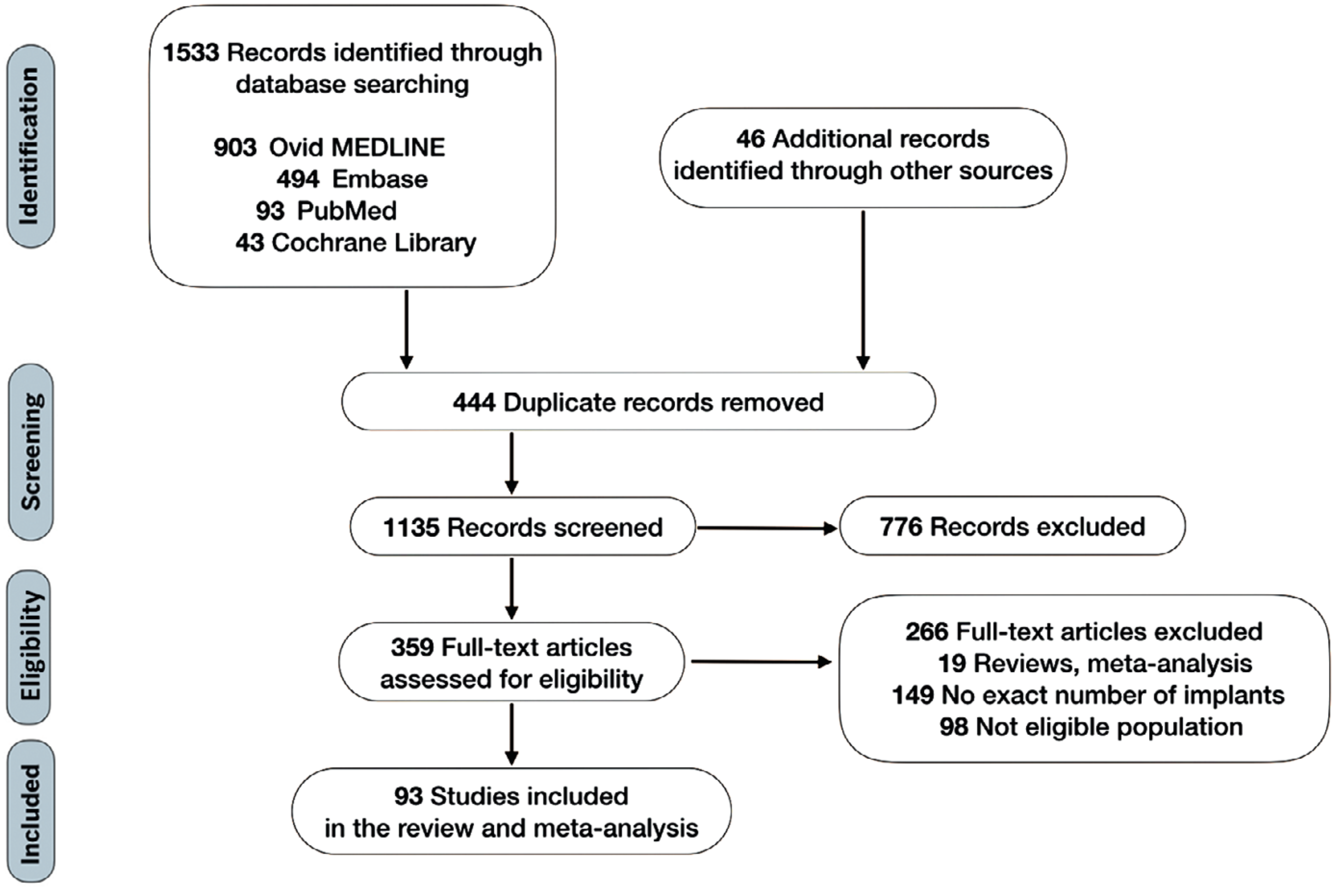

FIGURE 1 PRISMA flow diagram

of restorations (defined as a prosthesis reported to be in function, without the need for a complete replacement), per number of implants placed per arch. Secondary outcomes included distribution of implants, type of loading and form of retention.

2.6 | Risk of bias assessment

The risk of bias was assessed according to the type of study available. The nine RCTs available were assessed using the Cochrane Risk of Bias Tool (Higgins et al., 2011). The non-RCT studies of interventions included (42 prospective and 42 retrospective) were assessed for the risk of bias using the ROBINS-I tool (Risk Of Bias In Non-randomized Studies – of Intervention). It includes the risk of bias due to confounding factors, selection of participants into the study, classification of interventions, deviations from intended intervention, missing data, measurement of outcomes and selection of reported result (Sterne et al., 2016).

The reviewers ranked independently each included study and resolved any disagreement by reciprocal consulting.

2.7 | Statistical analysis

Assessment of heterogeneity was performed using Cochran's Q-statistic and the I^2 statistic model. Statistically significant heterogeneity between studies was observed, as indicated by the Q test and I^2 shown in Figures 2–5.

Due to the high heterogeneity of the selected studies, a decision was made to perform a meta-analysis using the random-effects model.

A random-effects meta-analysis was performed using R statistical software (random-effects model function from the metafor package), to compare papers reporting fewer than five implants with those reporting five or more implants for maxilla and mandible independently, as well as for implant and prosthesis survival rates. Additionally, the study type was also reported (randomized controlled trial, prospective, retrospective).

Forest plots were used to visualize the results for maxilla implants (Figure 2), maxilla prosthesis (Figure 3), mandible implants (Figure 4) and mandible prosthesis (Figure 5).

3 | RESULTS

A total of 1,533 references were identified through database searching, and an additional 46 from relevant bibliographies, for a total of 1,579 records identified (Figure 1). After removing 444 duplicates, 1,135 unique titles and abstracts were screened independently by two reviewers (*WDP* and *TA*), based on the defined inclusion and exclusion criteria.

First Author, Year	Implants Per Arch	Number of Implants	Survival Number	Survival Proportion [95% CI]
Prospective RCT				
Cannizaro, 2015	6	180	177	0.98 [0.96, 1.00]
Tallarico, 2016.1	6	120	114	0.95 [0.91, 0.99]
Toljanic, 2016	6	306	285	0.93 [0.90, 0.96]
Prospective RCT − 5+ Implants Per Arch (Q = 9.67, df = 2, p = 0.008; I^2 = 75.9%)				0.96 [0.92, 0.99]
Tallarico, 2016.2	4	80	79	0.99 [0.96, 1.00]
Cannizzaro, 2016.1	3	30	30	0.98 [0.94, 1.00]
Cannizzaro, 2017	3	60	57	0.95 [0.89, 1.00]
Cannizzaro, 2016.2	2	20	20	0.98 [0.91, 1.00]
Prospective RCT − <5 Implants Per Arch (Q = 1.52, df = 3, p = 0.677; I^2 = 0.0%)				0.98 [0.96, 1.00]
Prospective RCT − All Studies (Q = 12.97, df = 6, p = 0.043; I^2 = 55.3%)				0.97 [0.95, 0.99]
Prospective Cohort				
Ferrigno, 2002	8	440	419	0.95 [0.93, 0.97]
Zhang, 2016	8	83	81	0.98 [0.94, 1.00]
Degidi, 2010	7	210	205	0.98 [0.96, 1.00]
Agliardi, 2008	6	126	126	1.00 [0.99, 1.00]
Testori, 2008	6	240	235	0.98 [0.96, 1.00]
Toljanic, 2008	6	306	294	0.96 [0.94, 0.98]
Agliardi/Franceti, 2009	6	120	120	1.00 [0.98, 1.00]
Bergqvist, 2009	6	168	165	0.98 [0.96, 1.00]
Mertens, 2011	6	106	105	0.99 [0.97, 1.00]
Barbier, 2012	6	120	119	0.99 [0.98, 1.00]
Mertens, 2012	6	94	81	0.86 [0.79, 0.93]
Prospective Cohort − 5+ Implants Per Arch (Q = 37.03, df = 10, p = 0.000; I^2 = 71.5%)				0.98 [0.97, 0.99]
Agliardi, 2010	4	244	240	0.98 [0.97, 1.00]
Hinze, 2010	4	76	73	0.96 [0.92, 1.00]
Crespi, 2012	4	96	95	0.99 [0.97, 1.00]
Gherlone, 2016	4	68	68	0.99 [0.97, 1.00]
Najafi, 2016	4	56	55	0.98 [0.95, 1.00]
Piano, 2016	4	84	84	0.99 [0.98, 1.00]
Prospective Cohort − <5 Implants Per Arch (Q = 2.70, df = 5, p = 0.747; I^2 = 0.0%)				0.99 [0.98, 1.00]
Prospective Cohort − All Studies (Q = 40.08, df = 16, p = 0.001; I^2 = 53.4%)				0.98 [0.98, 0.99]
Retrospective				
Degidi, 2005	9	135	134	0.99 [0.98, 1.00]
Branemark, 1995.1	6	420	333	0.79 [0.75, 0.83]
Jemt, 2006	6	450	409	0.91 [0.88, 0.94]
Capelli, 2007	6	246	240	0.98 [0.96, 0.99]
Romanos, 2009	6	90	87	0.97 [0.93, 1.00]
Puig, 2010.1	6	84	82	0.98 [0.94, 1.00]
Antoun, 2012	6	78	77	0.99 [0.96, 1.00]
Thor, 2014	6	306	294	0.96 [0.94, 0.98]
Testori, 2017	6	144	137	0.95 [0.92, 0.99]
Wentascheck, 2017	6	60	57	0.95 [0.89, 1.00]
Retrospective − 5+ Implants Per Arch (Q = 112.50, df = 9, p = 0.000; I^2 = 94.6%)				0.95 [0.91, 0.98]
Branemark, 1995.2	4	56	45	0.80 [0.70, 0.91]
Malo, 2005	4	128	125	0.98 [0.95, 1.00]
Malo, 2007	4	72	70	0.97 [0.93, 1.00]
Puig, 2010.2	4	44	43	0.98 [0.93, 1.00]
Babbush , 2011	4	436	433	0.99 [0.99, 1.00]
Malo, 2011	4	716	696	0.97 [0.96, 0.98]
Parel, 2011	4	1140	1132	0.99 [0.99, 1.00]
Cavalli, 2012	4	136	136	1.00 [0.99, 1.00]
Malo, 2012	4	968	949	0.98 [0.97, 0.99]
Di, 2013	4	152	141	0.93 [0.89, 0.97]
Malo, 2013	4	280	275	0.98 [0.97, 1.00]
Balshi, 2014	4	300	289	0.96 [0.94, 0.98]
Malo, 2015	4	172	165	0.96 [0.93, 0.99]
Babbush, 2016	4	484	483	1.00 [0.99, 1.00]
Sannino, 2017	4	112	110	0.98 [0.96, 1.00]
Oliva, 2012	3	36	36	0.99 [0.95, 1.00]
Retrospective − <5 Implants Per Arch (Q = 65.06, df = 15, p = 0.000; I^2 = 81.4%)				0.98 [0.97, 0.99]
Retrospective − All Studies (Q = 219.06, df = 25, p = 0.000; I^2 = 97.0%)				0.96 [0.95, 0.98]
All Studies (Q = 281.89, df = 49, p = 0.000; I^2 = 92.6%)				0.97 [0.96, 0.98]
Studies with 5+ Implants Per Arch (Q = 180.91, df = 23, p = 0.000; I^2 = 93.3%)				0.96 [0.94, 0.98]
Studies with <5 Implants Per Arch (Q = 70.83, df = 25, p = 0.000; I^2 = 63.2%)				0.98 [0.98, 0.99]

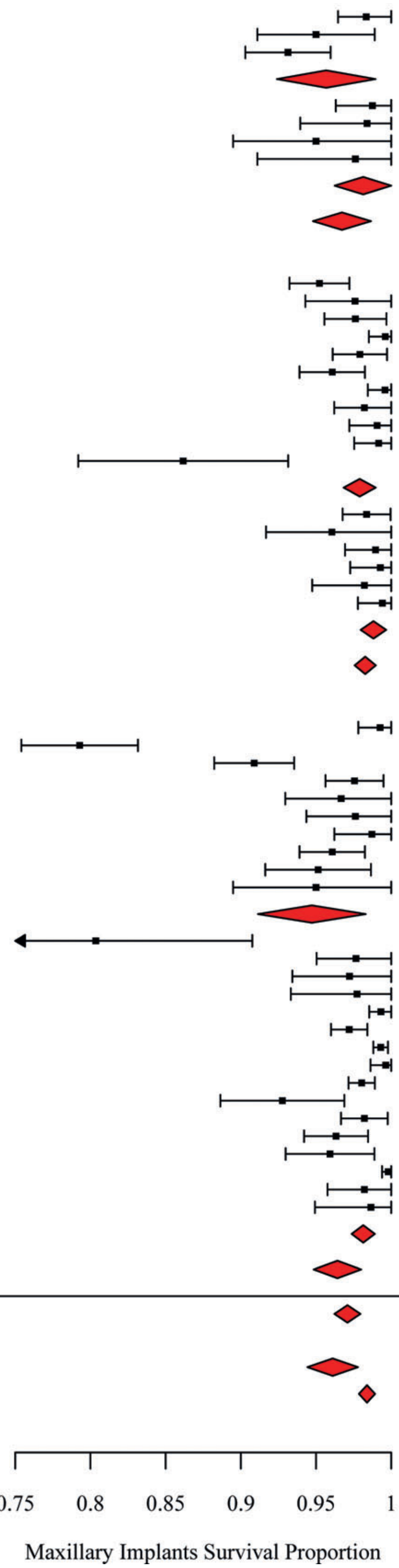

FIGURE 2 Meta-analysis forest plot—maxilla, implants

First Author, Year	Implants Per Arch	Number of Arches	Survival Number	Survival Proportion [95% CI]
Prospective RCT				
Cannizaro, 2015	6	30	30	0.98 [0.94, 1.00]
Tallarico, 2016.1	6	20	20	0.98 [0.91, 1.00]
Toljanic, 2016	6	51	50	0.98 [0.94, 1.00]
Prospective RCT − 5+ Implants Per Arch (Q = 0.04, df = 2, p = 0.981; I^2 = 0.0%)				0.98 [0.95, 1.00]
Tallarico, 2016.2	4	20	20	0.98 [0.91, 1.00]
Cannizzaro, 2016.1	3	10	8	0.80 [0.55, 1.00]
Cannizzaro, 2017	3	20	19	0.95 [0.85, 1.00]
Cannizzaro, 2016.2	2	10	8	0.80 [0.55, 1.00]
Prospective RCT − <5 Implants Per Arch (Q = 3.42, df = 3, p = 0.332; I^2 = 0.1%)				0.95 [0.90, 1.00]
Prospective RCT − All Studies (Q = 4.32, df = 6, p = 0.633; I^2 = 0.1%)				0.98 [0.95, 1.00]
Prospective Cohort				
Ferrigno, 2002	8	55	53	0.96 [0.91, 1.00]
Zhang, 2016	8	11	9	0.82 [0.59, 1.00]
Degidi, 2010	7	30	30	0.98 [0.94, 1.00]
Agliardi, 2008	6	21	21	0.98 [0.91, 1.00]
Testori, 2008	6	40	40	0.99 [0.95, 1.00]
Toljanic, 2008	6	51	51	0.99 [0.96, 1.00]
Agliardi/Franceti, 2009	6	20	20	0.98 [0.91, 1.00]
Bergqvist, 2009	6	28	28	0.98 [0.94, 1.00]
Mertens, 2011	6	17	17	0.97 [0.90, 1.00]
Barbier, 2012	6	20	20	0.98 [0.91, 1.00]
Mertens, 2012	6	15	14	0.93 [0.81, 1.00]
Prospective Cohort − 5+ Implants Per Arch (Q = 3.74, df = 10, p = 0.958; I^2 = 0.1%)				0.98 [0.97, 1.00]
Agliardi, 2010	4	61	61	0.99 [0.97, 1.00]
Hinze, 2010	4	19	19	0.97 [0.91, 1.00]
Crespi, 2012	4	24	24	0.98 [0.93, 1.00]
Gherlone, 2016	4	17	17	0.97 [0.90, 1.00]
Najafi, 2016	4	14	13	0.93 [0.79, 1.00]
Piano, 2016	4	21	21	0.98 [0.91, 1.00]
Prospective Cohort − <5 Implants Per Arch (Q = 1.32, df = 5, p = 0.933; I^2 = 0.0%)				0.99 [0.97, 1.00]
Prospective Cohort − All Studies (Q = 5.18, df = 16, p = 0.995; I^2 = 0.0%)				0.98 [0.97, 0.99]
Retrospective				
Degidi, 2005	9	15	15	0.97 [0.88, 1.00]
Branemark, 1995.1	6	70	70	0.99 [0.97, 1.00]
Jemt, 2006	6	76	69	0.91 [0.84, 0.97]
Capelli, 2007	6	41	41	0.99 [0.96, 1.00]
Romanos, 2009	6	15	15	0.97 [0.88, 1.00]
Puig, 2010.1	6	14	14	0.97 [0.88, 1.00]
Antoun, 2012	6	13	13	0.96 [0.87, 1.00]
Thor, 2014	6	51	47	0.92 [0.85, 1.00]
Testori, 2017	6	24	24	0.98 [0.93, 1.00]
Wentascheck, 2017	6	10	10	0.95 [0.83, 1.00]
Retrospective − 5+ Implants Per Arch (Q = 9.53, df = 9, p = 0.390; I^2 = 26.1%)				0.97 [0.95, 0.99]
Branemark, 1995.2	4	14	14	0.97 [0.88, 1.00]
Malo, 2005	4	32	32	0.98 [0.94, 1.00]
Malo, 2007	4	18	18	0.97 [0.90, 1.00]
Puig, 2010.2	4	11	11	0.96 [0.85, 1.00]
Babbush , 2011	4	109	109	1.00 [0.98, 1.00]
Malo, 2011	4	179	173	0.97 [0.94, 0.99]
Parel, 2011	4	285	285	1.00 [0.99, 1.00]
Cavalli, 2012	4	34	34	0.99 [0.95, 1.00]
Malo, 2012	4	242	242	1.00 [0.99, 1.00]
Di, 2013	4	38	37	0.97 [0.92, 1.00]
Malo, 2013	4	70	70	0.99 [0.97, 1.00]
Balshi, 2014	4	75	75	0.99 [0.98, 1.00]
Malo, 2015	4	43	42	0.98 [0.93, 1.00]
Babbush, 2016	4	121	121	1.00 [0.98, 1.00]
Sannino, 2017	4	28	28	0.98 [0.94, 1.00]
Oliva, 2012	3	12	12	0.96 [0.86, 1.00]
Retrospective − <5 Implants Per Arch (Q = 10.09, df = 15, p = 0.814; I^2 = 0.0%)				1.00 [0.99, 1.00]
Retrospective − All Studies (Q = 23.77, df = 25, p = 0.533; I^2 = 0.1%)				1.00 [0.99, 1.00]
All Studies (Q = 40.06, df = 49, p = 0.815; I^2 = 15.2%)				0.99 [0.99, 0.99]
Studies with 5+ Implants Per Arch (Q = 13.31, df = 23, p = 0.945; I^2 = 0.0%)				0.98 [0.97, 0.99]
Studies with <5 Implants Per Arch (Q = 18.71, df = 25, p = 0.811; I^2 = 1.7%)				1.00 [0.99, 1.00]

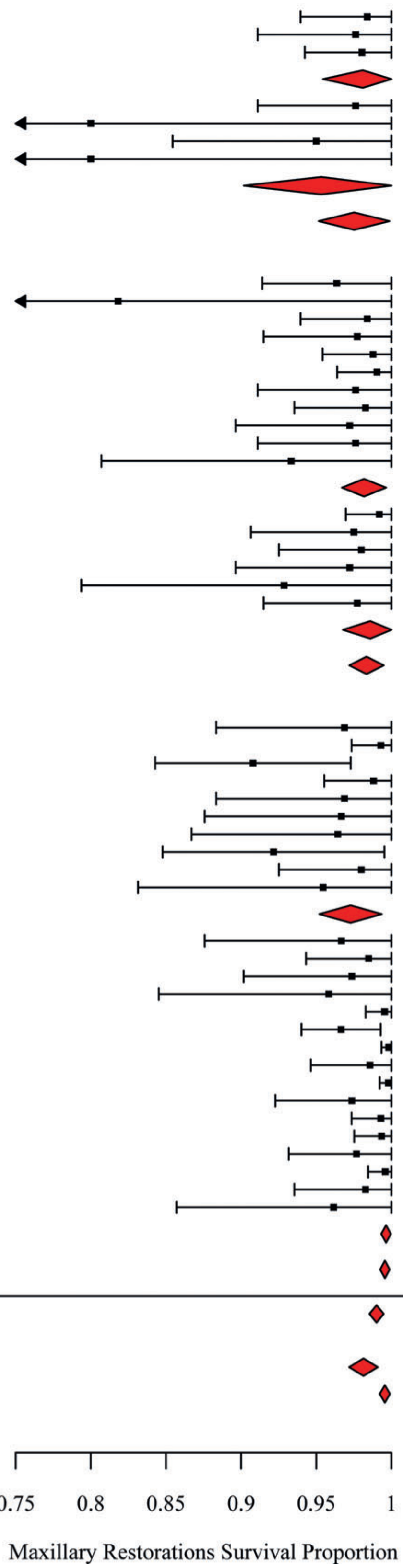

FIGURE 3 Meta-analysis forest plot—maxilla, prosthesis

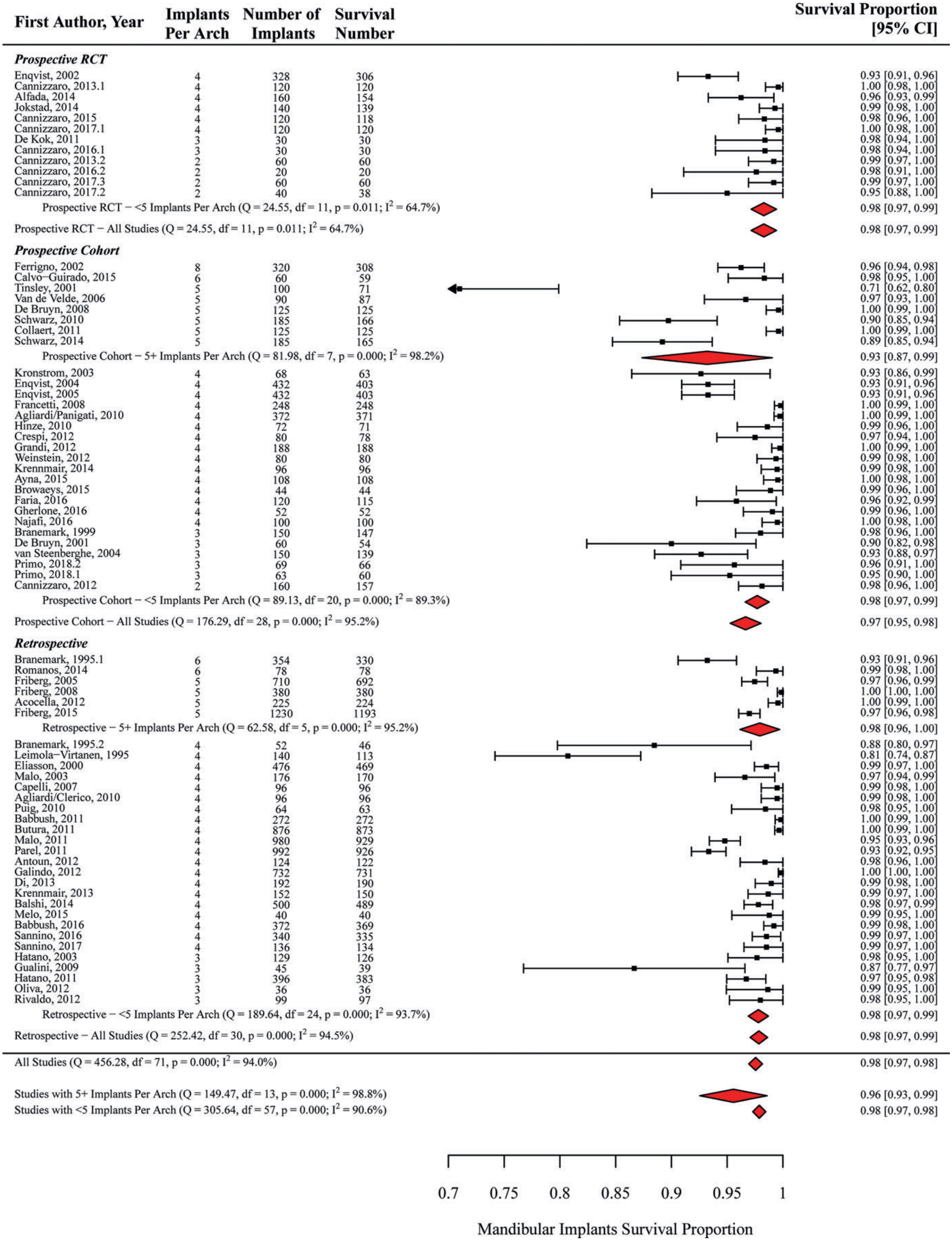

FIGURE 4 Meta-analysis forest plot—mandible, implants

First Author, Year	Implants Per Arch	Number of Arches	Survival Number	Survival Proportion [95% CI]
Prospective RCT				
Enqvist, 2002	4	82	82	0.99 [0.98, 1.00]
Cannizzaro, 2013.1	4	30	30	0.98 [0.94, 1.00]
Alfada, 2014	4	40	40	0.99 [0.95, 1.00]
Jokstad, 2014	4	35	35	0.99 [0.95, 1.00]
Cannizzaro, 2015	4	30	30	0.98 [0.94, 1.00]
Cannizzaro, 2017.1	4	30	30	0.98 [0.94, 1.00]
De Kok, 2011	3	10	10	0.95 [0.83, 1.00]
Cannizzaro, 2016.1	3	10	10	0.95 [0.83, 1.00]
Cannizzaro, 2013.2	2	30	30	0.98 [0.94, 1.00]
Cannizzaro, 2016.2	2	10	10	0.95 [0.83, 1.00]
Cannizzaro, 2017.3	2	30	30	0.98 [0.94, 1.00]
Cannizzaro, 2017.2	2	20	19	0.95 [0.85, 1.00]
Prospective RCT − <5 Implants Per Arch (Q = 2.13, df = 11, p = 0.998; I^2 = 0.0%)				0.99 [0.98, 1.00]
Prospective RCT − All Studies (Q = 2.13, df = 11, p = 0.998; I^2 = 0.0%)				0.99 [0.98, 1.00]
Prospective Cohort				
Ferrigno, 2002	8	40	40	0.99 [0.95, 1.00]
Calvo−Guirado, 2015	6	10	10	0.95 [0.83, 1.00]
Tinsley, 2001	5	20	17	0.85 [0.69, 1.00]
Van de Velde, 2006	5	18	18	0.97 [0.90, 1.00]
De Bruyn, 2008	5	25	25	0.98 [0.93, 1.00]
Schwarz, 2010	5	37	33	0.89 [0.79, 0.99]
Collaert, 2011	5	25	25	0.98 [0.93, 1.00]
Schwarz, 2014	5	37	31	0.84 [0.72, 0.96]
Prospective Cohort − 5+ Implants Per Arch (Q = 10.82, df = 7, p = 0.146; I^2 = 13.1%)				0.97 [0.94, 0.99]
Kronstrom, 2003	4	17	17	0.97 [0.90, 1.00]
Enqvist, 2004	4	108	108	1.00 [0.98, 1.00]
Enqvist, 2005	4	108	108	1.00 [0.98, 1.00]
Francetti, 2008	4	62	62	0.99 [0.97, 1.00]
Agliardi/Panigati, 2010	4	93	93	0.99 [0.98, 1.00]
Hinze, 2010	4	18	18	0.97 [0.90, 1.00]
Crespi, 2012	4	20	20	0.98 [0.91, 1.00]
Grandi, 2012	4	47	47	0.99 [0.96, 1.00]
Weinstein, 2012	4	20	20	0.98 [0.91, 1.00]
Krennmair, 2014	4	24	24	0.98 [0.93, 1.00]
Ayna, 2015	4	27	27	0.98 [0.93, 1.00]
Browaeys, 2015	4	11	11	0.96 [0.85, 1.00]
Faria, 2016	4	30	30	0.98 [0.94, 1.00]
Gherlone, 2016	4	13	13	0.96 [0.87, 1.00]
Najafi, 2016	4	25	25	0.98 [0.93, 1.00]
Branemark, 1999	3	50	49	0.98 [0.94, 1.00]
De Bruyn, 2001	3	20	17	0.85 [0.69, 1.00]
van Steenberghe, 2004	3	50	48	0.96 [0.91, 1.00]
Primo, 2018.2	3	23	23	0.98 [0.92, 1.00]
Primo, 2018.1	3	21	21	0.98 [0.91, 1.00]
Cannizzaro, 2012	2	80	78	0.97 [0.94, 1.00]
Prospective Cohort − <5 Implants Per Arch (Q = 9.04, df = 20, p = 0.982; I^2 = 0.0%)				0.99 [0.98, 1.00]
Prospective Cohort − All Studies (Q = 22.88, df = 28, p = 0.739; I^2 = 1.0%)				0.99 [0.98, 1.00]
Retrospective				
Branemark, 1995.1	6	59	59	0.99 [0.97, 1.00]
Romanos, 2014	6	13	13	0.96 [0.87, 1.00]
Friberg, 2005	5	142	142	1.00 [0.99, 1.00]
Friberg, 2008	5	76	76	0.99 [0.98, 1.00]
Acocella, 2012	5	45	30	0.67 [0.53, 0.80]
Friberg, 2015	5	259	255	0.98 [0.97, 1.00]
Retrospective − 5+ Implants Per Arch (Q = 23.55, df = 5, p = 0.000; I^2 = 98.9%)				0.95 [0.87, 1.00]
Branemark, 1995.2	4	13	13	0.96 [0.87, 1.00]
Leimola−Virtanen, 1995	4	37	32	0.86 [0.75, 0.98]
Eliasson, 2000	4	119	119	1.00 [0.98, 1.00]
Malo, 2003	4	44	44	0.99 [0.96, 1.00]
Capelli, 2007	4	24	24	0.98 [0.93, 1.00]
Agliardi/Clerico, 2010	4	24	24	0.98 [0.93, 1.00]
Puig, 2010	4	16	16	0.97 [0.89, 1.00]
Babbush, 2011	4	68	68	0.99 [0.97, 1.00]
Butura, 2011	4	219	219	1.00 [0.99, 1.00]
Malo, 2011	4	245	245	1.00 [0.99, 1.00]
Parel, 2011	4	273	273	1.00 [0.99, 1.00]
Antoun, 2012	4	31	30	0.97 [0.91, 1.00]
Galindo, 2012	4	183	183	1.00 [0.99, 1.00]
Di, 2013	4	48	46	0.96 [0.90, 1.00]
Krennmair, 2013	4	38	38	0.99 [0.95, 1.00]
Balshi, 2014	4	125	125	1.00 [0.99, 1.00]
Melo, 2015	4	10	10	0.95 [0.83, 1.00]
Babbush, 2016	4	93	93	0.99 [0.98, 1.00]
Sannino, 2016	4	85	85	0.99 [0.98, 1.00]
Sannino, 2017	4	34	34	0.99 [0.95, 1.00]
Hatano, 2003	3	43	42	0.98 [0.93, 1.00]
Gualini, 2009	3	15	14	0.93 [0.81, 1.00]
Hatano, 2011	3	132	122	0.92 [0.88, 0.97]
Oliva, 2012	3	12	12	0.96 [0.86, 1.00]
Rivaldo, 2012	3	33	33	0.99 [0.94, 1.00]
Retrospective − <5 Implants Per Arch (Q = 24.24, df = 24, p = 0.448; I^2 = 0.0%)				1.00 [0.99, 1.00]
Retrospective − All Studies (Q = 49.15, df = 30, p = 0.015; I^2 = 1.4%)				1.00 [0.99, 1.00]
All Studies (Q = 79.63, df = 71, p = 0.226; I^2 = 6.1%)				0.99 [0.99, 1.00]
Studies with 5+ Implants Per Arch (Q = 37.69, df = 13, p = 0.000; I^2 = 10.6%)				0.99 [0.98, 1.00]
Studies with <5 Implants Per Arch (Q = 39.82, df = 57, p = 0.959; I^2 = 0.0%)				1.00 [0.99, 1.00]

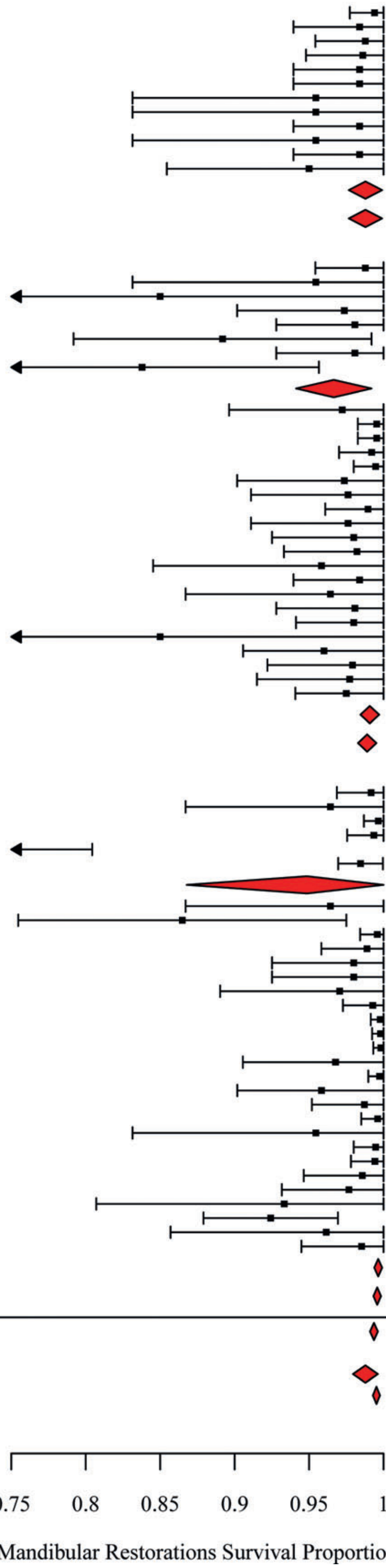

FIGURE 5 Meta-analysis forest plot—mandible, prosthesis

Full-text review was requested for 359 papers, and from those, 93 were selected and included in this review.

Main reasons for exclusion based on title/abstract review were fewer than 10 patients in the study, not exact number of implants per arch, combining survival rates for maxillary and mandibular implants, results for grafting procedures only, partial edentulism, overdentures, digital accuracy without reporting success of implants, maintenance issues and zygomatic implants. The reason for exclusion of the majority of papers after full-text review (149) was the lack of report on the exact number of implants utilized per arch, with reporting of averages only for the number of implants placed.

Of the 93 selected studies, 28 reported number of implants for the maxilla, 46 for the mandible and 19 for both maxilla and mandible, being nine RCTs, 42 prospective and 42 retrospective studies. Combining these studies for our focused analysis (exact number of implants per arch), 47 studies reported on rehabilitation for the maxilla and 65 for the mandible.

Three papers had two different groups for mandibular treatment, one had two groups for maxilla only (4 vs. 6 implants), one had three groups (two for the maxilla and one for the mandible), one had four groups (two for the maxilla and two for the mandible), and 19 had two groups (maxilla and mandible). Distributing the populations reported to both groups in the tables, led to a total

TABLE 1 Distribution of reports per number of implants—maxilla [In PDF format, this table is best viewed in two-page mode]

Number of implants per arch	First author	Year of publication	Study design	Total number of arches	Total number of implants	Position of implants per arch	Manufacturer/Type of implants
2	Cannizzaro	2016	Prospective RCT	10	20	Ant P	Prama RF Tapered
3	Oliva	2012	Retrospective	12	36	Ant P/Post DT	Straumann / Osstem
3	Cannizzaro	2016	Prospective RCT	10	30	Ant P	Prama RF Tapered
3	Cannizzaro	2017	Prospective RCT	20	60	Ant/Post P	Syra / Syra SL
4	Brånemark	1995	Retrospective	14	56	Parallel	Brånemark
4	Maló	2005	Retrospective	32	128	Ant P/Post DT	Nobel MKIII/MKIV TiUnite
4	Malo	2007	Retrospective	18	72	Ant P/Post DT	Nobel Speedy
4	Agliardi/Clerico	2010	Prospective	61	244	Ant P/Post DT	Nobel MKIV / Groovy
4	Hinze	2010	Prospective	19	76	Ant P/Post DT	Nanotite Tapered (Biomet 3i)
4	Puig	2010	Retrospective	11	44	Ant P/Post DT	Nobel Speedy Groovy/MK III Groovy
4	Malo	2011	Retrospective	179	716	Ant P/Post DT	Nobel MKIV / Groovy
4	Babbush	2011	Retrospective	109	436	Ant P/Post DT	Nobel Active
4	Parel	2011	Retrospective	285	1140	Ant P/Post DT	Nobel Active
4	Maló	2012	Retrospective	242	968	Ant P/Post DT	Brånemark / Nobel Speedy Groovy
4	Crespi	2012	Prospective	24	96	Ant P/Post DT	PAD Sweden-Martina
4	Cavalli	2012	Retrospective	34	136	Ant P/Post DT	Nobel MKIV / Groovy
4	Di	2013	Retrospective	38	152	Ant P/Post DT	Brånemark / Nobel Speedy Groovy
4	Maló	2013	Retrospective	70	280	Ant P/Post DT	Nobel
4	Balshi	2014	Retrospective	75	300	Ant P/Post DT	Nobel
4	Maló	2015	Retrospective	43	172	Ant P/Post DT	Nobel Speedy Groovy/Shorty
4	Tallarico	2016	Prospective RCT	20	80	Ant P/Post DT	Nobel Speedy
4	Babbush	2016	Retrospective	121	484	Ant P/Post DT	Nobel Active
4	Piano	2016	Prospective	21	84	Ant P/Post DT	Straumann Bone Level
4	Najafi	2016	Prospective	14	56	Ant P/Post DT	Nobel
4	Gherlone	2016	Prospective	17	68	Ant P/Post DT	IDI Evolution
4	Sannino	2017	Retrospective	28	112	Ant P/Post DT	Nobel Active/Speedy
6	Brånemark	1995	Retrospective	70	420	Parallel	Brånemark
6	Jemt	2006	Retrospective	76	450	Parallel	Brånemark
6	Capelli	2007	Retrospective	41	246	4 Ant P/2 Post DT	3i Osseotite NT
6	Testori	2008	Prospective	40	240	4 Ant P/2 Post DT	3i
6	Agliardi	2008	Prospective	21	126	Tilted V-II-V	Nobel MKIV (30)/ Groovy (96)
6	Toljanic	2009	Prospective	51	306	4 Ant P/2 Post DT	Astra Osseospeed
6	Bergqvist	2009	Prospective	28	168	Parallel	Straumann STL
6	Romanos	2009	Retrospective	15	90	Parallel	Ankylos

(Continues)

of 112 groups of patients analyzed (50 for the maxilla and 72 for the mandible).

Results for selected studies are presented in Tables 1 (maxilla) and 2 (mandible).

3.1 | Risk of bias of included studies

The risk of bias judgment for the nine RCTs is included in Table 3. Eight had a low risk of bias, and one had a high risk of bias. However, only one study (Tallarico, Meloni, Canullo, Caneva, and Polizzi (2016) was an RCT that addressed our focused question (fewer than five vs. five or more implants), comparing four vs. six implants.

The risk of bias analysis for the remaining 84 studies selected (42 prospective and 42 retrospective) was assessed using the ROBINS-I tool and is listed in Table 4. Nine studies had a low, 60 had a moderate, and 15 had a serious risk of bias.

3.2 | Maxillary outcomes (Table 1)

3.2.1 | Number of studies, implants and follow-up period

There were 50 groups of patients extracted from the 28 studies that reported numbers of implants for the maxilla (one RCT,

TABLE 1 (additional columns)

Mean follow-up years	Follow-up range	Survival implants (%)	Survival restoration (%)	Loading	Retention
1	12	100	82	Immediate provisional	Screw-retained
5	5 years	100	100	Conventional	Screw-retained
1	12	100	82	Immediate provisional	Screw-retained
1	12 months	95	95	Delayed	Screw-retained
10	10 years	80.30	100	Delayed	Screw-retained
1	12 months	97.60	100	Immediate provisional	Screw-retained
1.1	6–21 months	97	100	Immediate	Screw-retained
2.6	12–59 months	98.30	100	Immediate	Screw-retained
1	12 months	96.6	100	Immediate provisional	Screw-retained
1	12 months	98.00	100	Immediate provisional	Screw-retained
5	60 months	97.20	96.80	Immediate provisional	Screw-retained
1	12 months	99.30	100	Immediate provisional	Screw-retained
2.7	4–33 mos	99.30	100	Immediate provisional	Screw-retained
6.6	78.9–80.2 months	98	100	Immediate	Screw-retained
3	36 months	98.96	100	Immediate provisional	Screw-retained
3.2	12–73 months	100	100	Immediate provisional	Screw-retained
2.8	12–56 months	92.80	96.50	Immediate provisional	Screw-retained
3	36 months	98.10	100	Immediate provisional	Screw-retained
2.2	6–60 months	96.30	100	Immediate provisional	Screw-retained
3	4–75 months	95.70	98.20	Immediate provisional	Screw-retained
5.3	60–84 months	98.25	100	Immediate provisional	Screw-retained
1.3	12–36 months	99.80	100	Immediate provisional	Screw-retained
2	24 months	100	100	Immediate provisional	Screw-retained
3	32.5 ± 12.6	98	92	Immediate vs. delayed	Screw-retained
1	12 months	100	100	Immediate provisional	Screw-retained
2	24 months	100 (V), 98.38 (DT)	100	Immediate provisional	Screw-retained
10	10 years	79.30	100	Delayed	Screw-retained
15	15 years	90.90	90.60	Conventional	Screw-retained
1.8	6–36 months	97.59	100	Immediate provisional	Screw-retained
1	12 months	98	100	Immediate provisional	Screw-retained
1.6	4–35 Months	100	100	Immediate provisional	Screw-retained
1	12 months	96	100	Immediate provisional	Screw-retained
2.6	32 months	98.30	100	Immediate provisional	Screw-retained
3.6	22–62 months	96.66	100	Immediate provisional	Screw-retained

(Continues)

TABLE 1 (Continued) [In PDF format, this table is best viewed in two-page mode]

Number of implants per arch	First author	Year of publication	Study design	Total number of arches	Total number of implants	Position of implants per arch	Manufacturer/Type of implants
6	Agliardi	2009	Prospective	20	120	Tilted V-II-V	Nobel MKIV (30) / Groovy (90)
6	Puig	2010	Retrospective	14	84	4 Ant P/2 Post DT	Nobel Speedy Groovy/MK III Groovy
6	Mertens	2011	Prospective	17	106	Parallel	AstraTech
6	Antoun	2012	Retrospective	13	78	Parallel	Nobel
6	Barbier	2012	Prospective	20	120	Parallel	Astra Osseospeed
6	Mertens	2012	Prospective	15	94	Parallel	AstraTech
6	Thor	2014	Retrospective	51	306	Parallel	Astra Osseospeed
6	Cannizaro	2015	Prospective RCT	30	180	Parallel	3i
6	Tallarico	2016	Prospective RCT	20	120	Parallel	Nobel Speedy
6	Toljanic	2016	Prospective	51	306	4 Ant P/2 Post DT	Astra Osseospeed
6	Wentascheck	2017	Retrospective	10	60	4 Ant P/2 Post DT	Bredent BlueSky
6	Testori	2017	Retrospective	24	144	4 Ant P/2 Post DT	Biomet/3i
7	Degidi	2010	Prospective	30	210	Tilted V-III-V	Xive Plus Friadent
8	Ferrigno	2002	Prospective	55	440	Parallel	Straumann STL
8	Zhang	2016	Prospective	11	83	Parallel	Straumann
9	Degidi	2005	Retrospective	15	135	Parallel	Several

Ant, anterior; DT, distally tilted; P, parallel; Post, posterior; RCT, randomized controlled trial; V pos, position of the implants in the posterior maxilla, where the most distal implant is tilted mesially, and the implant just medial to it is tilted distally (in a 'V' shaped configuration); V-III-V, seven implants, two distal implants tilted, one mesially and one distally, and the three anterior parallel implants; V-II-V, six implants, two distal implants tilted, one mesially and one distally, and the two anterior parallel implants.

13 prospective and 14 retrospective), and from the 19 papers that reported for both groups (three RCTs, seven prospective and nine retrospective), for a total of 10,678 implants, followed for a median follow-up period of 8 years (1–15 years). Distribution of papers per number of implants for the maxilla is presented in Table 1.

Twenty-six groups had fewer than five implants, with a median follow-up time of 5.5 years (1–10 years), reported in 25 papers. One study reported on two and three implants, two reported on three implants, and 22 reported on four implants. Looking only at studies with four implants, the median follow-up time was 5.5 years (1–10 years).

Twenty-four groups had five or more implants per arch, with a median follow-up time of 8 years (1–15 years), being 20 studies reporting on six implants, and four studies reporting on more than six implants.

3.2.2 | Implant and restoration survival rates

Overall mean implant survival rate was 96%, and restoration survival rate was 99%, for a follow-up range from 1 to 15 years, with median follow-up of 8 years. For reports with fewer than five implants (26 studies), mean reported implant survival rate was 97%, and restoration survival rate was 98%, with a median follow-up time of 5.5 years (1–10 years). Looking only at the 22 studies with four implants, the mean implant survival rate was 97%, with a restoration survival rate of 99%, in a median follow-up of 5.5 years (range 1–10 years).

For the 24 reports with five or more implants, implant survival rate had a mean of 95%, and restoration survival rate was 98.5%, in a median follow-up of 8 years (1–15 years). Looking only at the 20 studies that reported on six implants per maxillary arch, mean implant survival rate was 95%, and restoration survival rate was 98.5%, in a follow-up range of 1–15 years (median of 8 years).

3.2.3 | Implant distribution

Overall, the configuration of "anterior parallel and posterior distally tilted" was used in 32 groups, whereas the "parallel" position was used in 18 reports.

When looking at the group with fewer than five implants, 22 of 26 reported on "anterior parallel and posterior distally tilted," and four were "parallel." Of the 22 papers reporting on four implants for edentulous maxillae, only one had the four implants placed in a "parallel" fashion (Brånemark et al., 1995), with a mean survival rate of 80.3% for the smooth surface implants. The other 18 papers reported the implant position as being "two anterior parallel and two posterior intentionally distally tilted," with a mean implant survival rate of 97.8% and prosthesis survival rate of 99% (follow-up 1–6.6 years, median of 3.8 years).

Analyzing the reports with five or more implants in the maxilla, the use of "anterior parallel and posterior distally tilted" was indicated in 10 reports, and the "parallel" implants were used in 18 reports. When six implants were placed, distribution varied between "parallel" (11 papers), "four anterior parallel and two posterior distally tilted" (seven papers), and two papers reported a position with "two anterior implants parallel, two anteriorly tilted mesially and two posteriorly tilted distally" configuration (V-II-V). The average

TABLE 1 (additional columns - continued)

Mean follow-up years	Follow-up range	Survival implants (%)	Survival restoration (%)	Loading	Retention
2.3	17–42 months	100	100	Immediate provisional	Screw-retained
1	12 months	98	100	Immediate provisional	Screw-retained
8	8 years	99	100	Conventional	Screw-retained
1.5	3–56 months	98.50	97.70	Immediate	Screw-retained
1	6–18 months	99.30	100	Immediate provisional	Screw-retained
11.3	10.42–12.25 years	86.70	93.30	Conventional	Screw-retained
3	36 months	96	92.50	Immediate provisional	Screw-retained
1	12	98.50	100	Immediate provisional	Screw-retained
5.3	60–84 months	95	100	Immediate provisional	Screw-retained
5	5 years	93	97.50	Immediate provisional	Screw-retained
5.3	42–84 months	95	100	Immediate provisional	Screw-retained
10	10 years	95	100	Immediate provisional	Screw-retained
3	36 months	97.8 (ax) 99.2 (tilt)	100	Immediate	Screw-retained
10	5–10 years	95.30	96.40	Early	Screw-retained
10	1, 3, 5, 10 years	97.60	79 (segmented)	Delayed	Cemented
5	60 months	99.20	100	Immediate provisional	Screw-retained

survival rate reported for six parallel placed implants to support a fixed prosthesis was of 95% and survival rate of the prosthesis of 95%, with a median follow-up time of 8 years (1–15 years). Looking only at the seven papers that reported the distribution of being "four anterior parallel and two posterior distally tilted," the median follow-up time was 5.5 years (1–10 years), and a survival rate was 96% for both the implants and prosthesis. Papers reporting more than six implants had all implants parallel to each other. There was no significant difference in implant and prosthesis survival between the different implant distributions, although it was clear that when four implants are placed, the preferred configuration is the "anterior parallel, posterior distally tilted," and when six implants were placed, there was a slight preference to use the "parallel" configuration, with a trend on more recent papers to use the "four anterior parallel and two posterior distally tilted" configuration. The influence of tilted or inclined implants is the focus of a separate systematic review of this Supplement (Lin & Eckert, 2018).

3.2.4 | Loading protocols

Immediate loading was performed in 41 reports in the maxilla (nine with conventional loading). Overall, the immediate loading had a survival rate of 96% for both implants and prosthesis, with a follow-up range of 1–10 years (median of 5.5 years). All the reports with fewer than five implants except one (Brånemark et al., 1995) reported immediate loading with a screw-retained immediate provisional prosthesis, meaning that 21 reports on the use of four implants used immediate loading, showing a mean implant survival rate of 97.8% and prosthesis survival rate of 99% (follow-up 1–6.6 years, median of 3.8 years). Of the papers reporting on five or more implants, only six reported using delayed or conventional loading, whereas 18 reported on immediate loading. All reported screw-retention for the prostheses. For the group with six implants, 16 reported immediate loading, and four conventional or early loading. There was no significant difference between outcomes of loading protocols when comparing the main two groups (four vs. six implants), with a clear preference for the "immediate loading" protocol.

3.3 | Mandibular outcomes (Table 2)

3.3.1 | Number of studies, implants and follow-up period

There were 72 groups that reported numbers of implants for the mandible, in data extracted from 46 papers that reported only cases for the mandible (five RCTs, 22 prospective and 19 retrospective), and 19 that reported for both maxilla and mandible (three RCTs, seven prospective and nine retrospective studies), for a total of 12,697 implants. The follow-up reported ranged from 1 to 10 years, with a median of 5.5 years. Distribution of papers per number of implants for the mandible is presented in Table 2.

Fifty-four groups were included in the fewer than five implants analysis, including five reports on two implants, 12 reported on three implants, and 41 reported on four implants per arch. Follow-up range was from 1 to 10 years (median of 5.5 years). One study had a

TABLE 2 Distribution of reports per number of implants—mandible [In PDF format, this table is best viewed in two-page mode]

Number of implants per arch	First author	Year of publication	Study design	Total number of arches	Total number of implants	Position of implants per arch	Manufacturer/Type of implants
2	Cannizzaro	2012	Prospective	80	160	BMF P	3i Osseotite
2	Cannizzaro	2013	Prospective RCT	30	60	BMF P	3i Osseotite/Osteogen
2	Cannizzaro	2016	Prospective RCT	10	20	BMF P	Prama RF Tapered
2	Cannizzaro	2017	Prospective RCT	20	40	BMF P	Syra / Syra SL
2	Cannizzaro	2017	Prospective RCT	30	60	BMF P and DT	Zimmer/Biomet—Megagen
3	Brånemark	1999	Prospective	50	150	BMF P	Nobel Novum
3	De Bruyn	2001	Prospective	20	60	BMF P	Brånemark
3	Hatano	2003	Retrospective	43	129	BMF P and DT	Brånemark
3	van Steenberghe	2004	Prospective	50	150	BMF P	Brånemark Novum
3	Gualini	2009	Retrospective	15	45	BMF P	Brånemark Novum
3	De Kok	2011	Prospective RCT	10	30	BMF P	Astra Osseospeed
3	Hatano	2011	Retrospective	132	396	BMF P	Brånemark
3	Rivaldo	2012	Retrospective	33	99	BMF P	Brånemark
3	Oliva	2012	Retrospective	12	36	BMF P	Straumann / Osstem
3	Cannizzaro	2016	Prospective RCT	10	30	BMF P	Prama RF Tapered
3	Primo	2018	Prospective	21	63	BMF P and DT	Brånemark
3	Primo	2018	Prospective	23	69	BMF P and DT	Brånemark
4	Leimola-Virtanen	1995	Retrospective	37	140	BMF P	ITI TPS
4	Brånemark	1995	Retrospective	13	52	BMF P	Brånemark
4	Eliasson	2000	Retrospective	119	476	BMF P	Brånemark
4	Engquist	2002	Prospective	82	328	BMF P	Brånemark
4	Maló	2003	Retrospective	44	176	BMF DT	Brånemark
4	Kronström	2003	Prospective	17	68	BMF DT	Brånemark MK IV
4	Engquist	2004	Prospective	108	432	BMF P	Brånemark
4	Engquist	2005	Prospective	108	432	BMF P	Brånemark
4	Capelli	2007	Retrospective	24	96	BMF DT	3i Osseotite NT
4	Francetti	2008	Prospective	62	248	BMF DT	Nobel MK IV/Nobel Speedy Groovy
4	Hinze	2010	Prospective	18	72	BMF DT	Nanotite Tapered (Biomet 3i)
4	Agliardi/Panigati	2010	Prospective	93	372	BMF DT	Nobel MK IV/Nobel Groovy
4	Puig	2010	Retrospective	16	64	BMF DT	Nobel Speedy Groovy/MK III Groovy
4	Agliardi/Clerico	2010	Retrospective	24	96	BMF DT	Nobel MK IV/Nobel Groovy
4	Babbush	2011	Retrospective	68	272	BMF DT	Nobel Active
4	Parel	2011	Retrospective	273	992	BMF DT	Nobel Active
4	Butura	2011	Retrospective	219	876	BMF DT	Brånemark
4	Malo	2011	Retrospective	245	980	BMF DT	Brånemark MK II, III, IV
4	Weinstein	2012	Prospective	20	80	BMF DT	Brånemark MKIV/Nobel Groovy
4	Crespi	2012	Prospective	20	80	BMF DT	PAD Sweden-Martina
4	Grandi	2012	Prospective	47	188	BMF DT	JD Evolution
4	Galindo	2012	Retrospective	183	732	BMF DT	Nobel Active/Groovy Speedy
4	Antoun	2012	Retrospective	31	124	BMF DT	Nobel
4	Cannizzaro	2013	Prospective RCT	30	120	BMF P	3i Osseotite/Osteogen
4	Di	2013	Retrospective	48	192	BMF DT	Brånemark / Nobel Speedy Groovy
4	Krennmair	2013	Retrospective	38	152	BMF DT	Screwline, Camlog
4	Krennmair	2014	Prospective	24	96	BMF DT	Screwline, Camlog
4	Alfadda	2014	Prospective RCT	40	160	BMF P	Nobel TiUnite

(Continues)

TABLE 2 (additional columns)

Mean follow-up Years	Follow-up range	Survival implants (%)	Survival restoration (%)	Loading	Retention
1	12 months	98	98	Immediate provisional	Screw-retained
1	12 months	100	100	Immediate provisional	Screw-retained
1	12 months	100	100	Immediate provisional	Screw-retained
1	12 months	95	95	Delayed	Screw-retained
3	36 months	100	100	Immediate provisional	Screw-retained
1.8	6–36 months	98	98	Immediate	Screw-retained
3	36 months	90	85	Delayed	Screw-retained
2.2	3–49 months	97.30	97	Immediate	Screw-retained
1	12 months	92.70	95	Immediate	Screw-retained
5	42–62 months	87	91	Immediate	Screw-retained
1	12 months	100	100	Delayed	Screw-retained
5	12–132 months	96.70	92.40	Immediate	Screw-retained
1.5	18 months	97.80	100	Immediate	Screw-retained
5	5 years	100	100	Delayed	Screw-retained
1	12	100	100	Immediate provisional	Screw-retained
1.5	18 months	95	100	Immediate provisional	Screw-retained
1.5	18 months	96	100	Delayed	Screw-retained
5.6	3–10 years	80.80	86.80	Delayed	Screw-retained
10	10 years	88.40	100	Delayed	Screw-retained
6	3 years	98.60	100	Delayed	Screw-retained
1	12 months	93.2 to 97.5	100	Different groups	Screw-retained
1.2	6–36 months	96.70	100	Immediate provisional	Screw-retained
1	12 months	93	100	Delayed	Screw-retained
1	12 months	93.2 to 97.5	100	Different groups	Screw-retained
3	36 months	93.2 to 93.3	100	Different groups	Screw-retained
2.4	6–36 months	100	100	Immediate provisional	Screw-retained
1.9	6–43 months	100	100	Immediate provisional	Screw-retained
1	12 months	98.70	100	Immediate provisional	Screw-retained
2.2	12–55 months	99.73	100	Immediate	Screw-retained
1	12 months	98.00	100	Immediate provisional	Screw-retained
2.7	19–47 months	100	100	Immediate	Screw-retained
1	12 months	100	100	Immediate provisional	Screw-retained
2.7	4–33 mos	93.30	100	Immediate	Screw-retained
3	36 months	99.66	100	Immediate	Screw-retained
10	5 and 10 years	94.80	100	Immediate	Screw-retained
2.5	20–48 months	100	100	Immediate provisional	Screw-retained
3	36 months	97.50	100	Immediate provisional	Screw-retained
1.5	18 months	100	100	Immediate provisional	Screw-retained
1	12 m,onths	99.86	100	Immediate provisional	Screw-retained
1.5	3–56 months	98.50	97.70	Immediate	Screw-retained
1	12 months	100	100	Immediate provisional	Screw-retained
2.8	12–56 months	99	96.50	Immediate provisional	Screw-retained
5.5	5–7 years	98.60	100	Conventional	Screw-retained
2	24 months	100	100	Immediate provisional	Screw-retained
1	12 months	96	100	Different groups	Screw-retained

(Continues)

TABLE 2 (Continued) [In PDF format, this table is best viewed in two-page mode]

Number of implants per arch	First author	Year of publication	Study design	Total number of arches	Total number of implants	Position of implants per arch	Manufacturer/Type of implants
4	Jokstad	2014	Prospective RCT	35	140	BMF P	Nobel MK III/MK IV TiUnite
4	Balshi	2014	Retrospective	125	500	BMF DT	Nobel
4	Ayna	2015	Prospective	27	108	BMF DT	Nobel Speedy
4	Cannizzaro	2015	Prospective RCT	30	120	BMF P/D	3i Osseotite
4	Browaeys	2015	Prospective	11	44	BMF P and DT	Nobel MKIII Groovy
4	Melo	2015	Retrospective	10	40	BMF P	Neodent
4	Gherlone	2016	Prospective	13	52	BMF DT	IDI Evolution
4	Faria	2016	Prospective	30	120	BMF P	Astra TiOblast
4	Najafi	2016	Prospective	25	100	BMF DT	Nobel
4	Babbush	2016	Retrospective	93	372	BMF DT	Nobel Active
4	Sannino	2016	Retrospective	85	340	BMF DT	Nobel Active/Speedy
4	Cannizzaro	2017	Prospective RCT	30	120	BMF DT	Zimmer/Biomet—Megagen
4	Sannino	2017	Retrospective	34	136	BMF DT	Nobel Active/Speedy
5	Tinsley	2001	Prospective	20	100	BMF P	Calcitek
5	Friberg	2005	Retrospective	142	710	BMF P	Brånemark Smooth
5	Van de Velde	2007	Prospective	18	90	BMF P	Brånemark MKIII/MK IV
5	Friberg	2008	Retrospective	76	380	BMF P	Nobel MK III TiUnite
5	De Bruyn	2008	Prospective	25	125	BMF P	Astra TiOblast
5	Schwarz	2010	Prospective	37	185	BMF P	Frialoc
5	Collaert	2011	Prospective	25	125	BMF P	Astra Osseospeed
5	Acocella	2012	Retrospective	45	225	BMF DT	Astra
5	Schwarz	2014	Prospective	37	185	BMF P	Frialoc
5	Friberg	2015	Retrospective	259	1230	BMF P	Brånemark/TiUnite
6	Brånemark	1995	Retrospective	59	354	Parallel	Brånemark
6	Romanos	2014	Retrospective	13	78	Parallel	Ankylos
6	Calvo-Guirado	2016	Prospective	10	60	BMF P + DS	Straumann
8	Ferrigno	2002	Prospective	40	320	Parallel	Straumann STL

BMF, between mental foramen; D, distal; DT, distally tilted; P, parallel; V, position of the maxillary implants in the posterior maxilla, where the most distal implant is tilted mesially, and the implant just medial to it is tilted distally (in a 'V' shaped configuration).

comparison between two and four implants, and another compared two and three implants.

Fourteen groups with five or more implants per arch were included, with 10 groups reporting on five implants, three studies on six implants, and one study on eight implants per arch. Follow-up range was from 1 to 10 years (median of 5.5 years).

3.3.2 | Implant and restoration survival rates

Overall mean implant survival rate was 97%, and restoration survival rate was 99%, for a median follow-up period of 5.5 years (range 1–10 years). For the 58 groups with fewer than five implants, mean reported implant survival rate was 97% and restoration survival rate was 99%. The majority of the studies (41) reported on four implants, with a mean implant survival rate of 98%, and restoration survival rate of 99%, with a median follow-up time of 5.5 years (range 1–10 years). Twelve reports on the use of three implants to support a fixed prosthesis were identified, with a survival rate of 96.3% for implants and 97% for the prosthesis, with a follow-up period of 1–5 years (median of 3 years).

For reports with five or more implants (14 studies), mean implant survival rate was 95%, and restoration survival rate was 98%. Looking at the 10 studies that reported on five implants per mandibular arch, mean implant survival rate was 93%, and restoration survival rate was 95%, with an observation period of 1–10 years (median of 4.1 years).

There was no significant difference for implant and prosthesis survival rates between less than five compared to five or more implants, but there is a clear preference for the use of four implants to support a complete-arch fixed prosthesis in the mandible, with a trend to use only three implants in more recent papers.

3.3.3 | Implant distribution

Analyzing the 58 identified reports on fewer than five implants for edentulous mandibles, 27 reported on implants positioned parallel to each other, between the mental foramen, with the mean implant survival rate of 95.9% and restoration survival of 98%. The remaining 31 had the two implants positioned closer to the midline, parallel

TABLE 2 (additional columns - continued)

Mean follow-up Years	Follow-up range	Survival implants (%)	Survival restoration (%)	Loading	Retention
5	60 months	99	100	Different groups	Screw-retained
2.2	6–60 months	97.80	100	Immediate provisional	Screw-retained
5	60 months	100	100	Immediate provisional	Screw-retained
1	12 Months	98.50	100	Immediate provisional	Screw-retained
3	36	100	100	Immediate provisional	Screw-retained
7	7 years	100	100	Immediate	Screw-retained
1	12 months	100	100	Immediate provisional	Screw-retained
2	24 months	95.83	100	Immediate provisional	Screw-retained
3	32.5 ± 12.6	100	100	Different groups	Screw-retained
1.3	12–36 months	99.30	100	Immediate provisional	Screw-retained
3	36 months	98.60	100	Immediate provisional	Screw-retained
3	36 months	100	100	Immediate provisional	Screw-retained
2	24 months	100 (V), 98.38 (DT)	100	Immediate provisional	Screw-retained
5	48–72 months	71	85	Conventional	Screw-retained
1	12 months	97.50	100	Delayed	Screw-retained
3.7	26–57 months	96.70	100	Immediate provisional	Screw-retained
1	12 months	100	100	Delayed	Screw-retained
3	36 months	100	100	Immediate provisional	Screw-retained
7.2	1–8 years	89.70	89.20	Immediate provisional	Screw-retained
2	24 months	100	100	Immediate provisional	Screw-retained
4	48 months	99.50	97.80	Immediate	Screw-retained
7.2	2–14 years	89.20	83.80	Immediate provisional	Screw-retained
5	60 months	97/99.7	98.50	Different groups	Screw-retained
10		93.20	100	Delayed	Screw-retained
6.3	6.3–134 months	100	100	Immediate provisional	Screw-retained
1	12 months	100 (P)/99(Short)	100	Delayed	Screw-retained
5	5–10 years	96.40	100	Early	Screw-retained

to each other, and the two distal implants tilted posteriorly. The mean survival rates for tilted implants in a four implant configuration were 98.6%, and the restoration survival rate was 100%. When three implants were placed (12 reports), the configuration was not always clearly reported for all papers. It varied between "parallel" and "posterior distally tilted" implants, even within the same groups, as well as one in the midline and the two distal ones as posterior as bone allowed.

When more than five implants were placed (14 studies), implant positions were parallel for 12 studies, with a reported mean survival rate of 98% for implants and 100% for prosthesis, with a median follow-up of 5.5 years (1–10 years). Only two groups with five or more implants had the distal implants tilted. One study (Calvo-Guirado et al., 2016) presented the use of six implants per arch, with two extra-short implants placed in each posterior quadrant of each edentulous mandible. These were splinted with two longer anterior implants positioned between mental foramens. Survival rates were 97.5% for the short implants and 100% for the 10-mm-long implants, with a restoration survival rate of 100% after 1 year.

3.3.4 | Loading considerations

Immediate loading was performed in 51 of the 72 groups reporting mandibular implants. Forty-eight of the 51 reports were on the group with fewer than five implants, with a mean implant survival rate of 98% and prosthesis survival rate of 99%, with a median follow-up reported of 5.5 years (range 1–10 years). Fifteen reports had conventional loading (10 in fewer than five and five in five or more), with an average implant survival rate of 94%, and average prosthesis survival rate of 96%, with reported follow-up of 1–10 years (median 5.5 years). Six papers reported a comparison between immediate and conventional (delayed) loading, and they reported no significant difference between the two loading protocols. There was no significant difference between loading protocols used for <5 when compared to 5 or more implants.

3.3.5 | Meta-analysis

Statistically significant heterogeneity between studies was observed, as indicated by the Cochran's Q test and I^2 shown in the Figures 2–5.

TABLE 3 Risk of bias assessment for RCTs—COCHRANE Tool

First author	Year of publication	Study design	Random sequence generation (Selection bias)	Blinding of participants and personnel (Performance bias)	Blinding of outcome assessment (Detection bias)	Incomplete outcome data (Attrition bias)	Selective reporting (Reporting bias)	Other sources of bias	Overall risk of bias	Comments
Alfadda	2014	Prospective RCT	Low risk	Low risk	Unclear risk	Low risk	Low risk	None	Low risk	Mand 4—Immediate vs. Delayed loading
Cannizzaro	2013	Prospective RCT	Low risk	Low risk	Low risk	Low risk	Low risk	None	Low risk	Mand Ao2 vs. Ao4—1 year
Cannizzaro	2015	Prospective RCT	Low risk	Low risk	Unclear risk	Unclear risk	Low risk	None	Low risk	Mand (4) and Max (6) / Short vs. Long
Cannizzaro/ Felice	2017	Prospective RCT	Low risk	Low risk	Low risk	Low risk	Low risk	None	Low risk	Mand Ao2 vs. Ao4—3 years
Cannizzaro/ Gastaldi	2017	Prospective RCT	Low risk	Low risk	Low risk	Low risk	Low risk	None	Low risk	Max 3 / Mand 4—Rough vs. Smooth
Cannizzaro/ Loi	2016	Prospective RCT	High risk	High risk	Low risk	Unclear risk	Low risk	None	High risk	Mand & Max—2 vs. 3 Imm Load
De Kok	2011	Prospective RCT	Low risk	Unclear risk	Unclear risk	Low risk	Low risk	None	Unclear risk	Mand 3 - vs. Overd 2
Jokstad	2014	Prospective RCT	Low risk	Low risk	Unclear risk	Low risk	Low risk	None	Low risk	Mand 4—Immediate vs. Delayed
Tallarico	2016	Prospective RCT	Low risk	Low risk	Low risk	Low risk	Low risk	None	Low risk	Max—4 vs. 6

Hence, a decision was made to perform a meta-analysis using the random-effects model.

All outcomes were dichotomous. The total number of implants and the number of implants without observed failure were used in the calculation of the survival proportion/survival rate for the implants. The survival of the implants/prosthesis refers to the presence or absence of implant/ prosthesis survival or the proportion surviving. The number of arches and the number of prosthesis without observed failure were used in the calculation of the survival proportion and survival rate for the prosthesis.

The proportions of survival along with 95% confidence intervals were estimated for all studies, by study type (randomized controlled trial, prospective, retrospective), by number of implants placed per arch, and by both factors. p-values <0.05 were considered statistically significant.

Overall implant and prosthesis survival was high, at 95% CI. No significant differences were found between the study types (prospective, RCT, retrospective) or when comparing studies with fewer than five implants per arch with five or more implants per arch ($p > 0.05$), for both maxillary and mandibular rehabilitations. Forest plots are presented in Figure 2 (maxilla, implants), Figure 3 (maxilla, restorations), Figure 4 (mandible, implants) and Figure 5 (mandible, restorations).

4 | DISCUSSION

4.1 | Initial considerations

The number of implants utilized to support a complete-arch prosthesis is one of the first topics discussed since the beginning of implant dentistry and still remains of interest, due to the several implications derived from the influence on the outcomes regarding the decision to place less or more implants. Initial observation from papers included in our review shows that there is a trend to use less implants, distributed with an adequate antero-posterior spread in the arch.

However, this systematic review found a lack of high-quality evidence publications dealing with the number of implants to be placed to support a complete-arch fixed prosthesis. Only nine randomized clinical trials were included, but more importantly, just one was a RCT that addressed our focused question (less than five vs. five or more implants).

It was clear that evidence from randomized trials was not sufficient to answer questions of interest to patients and healthcare providers, related to the number of implants to support a complete-arch prosthesis. Hence, we needed to include nonrandomized studies (prospective and retrospective), due to the lack of sufficient number of randomized controlled trials examining the outcomes for different number of implants. A larger number of studies were included, and the quality of evidence and the risk of bias was assessed using the ROBINS-I assessment tool.

The ROBINS-I is based on the Cochrane Risk of Bias tool for randomized trials and uses the domain-based assessment, explained in a comprehensive manual in which users can interpret the results in a similar way, thus reducing the risk of subjective evaluation (Sterne et al., 2016).

As stated by Black (1996), nonrandomized studies can provide evidence additional to that available from randomized trials about long-term outcomes, rare events, adverse effects and populations that are typical of real world practice. Using the ROBINS-I tool, the risk of bias of nonrandomized studies of interventions was assessed to be from moderate to serious, and caution has to be taken when analyzing the findings of the studies included in this systematic review of the literature (Table 4). With the above in mind, we present the summary of our findings as follows.

4.2 | Summary of main findings

This review demonstrates similar outcomes (implant and prosthesis survival) when comparing less than five to five or more supporting implants, for both the maxilla and the mandible. The results also demonstrate a larger number of studies reporting on high survival rates for the use of four (22 papers, mean implant survival rate of 97%, with a prosthesis survival rate of 99%, median follow-up of 5.5 years, range 1–10 years), and six implants (20 papers, mean implant survival rate of 95%, prosthesis survival rate of 98.5%, follow-up range of 1–15 years, median of 8 years), to support a one-piece complete-arch fixed prosthesis on the maxilla, and four implants (41 papers, implant rate survival of 97%, restoration survival of 99%, average follow-up time of 2.8 years) to support a one-piece full-arch fixed mandibular prosthesis.

Nonetheless, the authors recognize that the antero-posterior distribution of the implants is also of importance and ideally should be correlated with the number of implants, as it has a direct impact on the survival of implants and on technical complications (Heydecke et al., 2012; Papaspyridakos, Chen, Chuang, Weber, & Gallucci, 2012).

When looking at studies that report on fewer than five implants per maxillary arch, one paper reported a fixed rehabilitation using only two implants (Cannizzaro et al., 2016), and the same publication also reported on three implants per maxillary arch. Survival rates reported were of 82%, lower than the average reported for papers using four implants. Oliva, Oliva, and Oliva (2012) discussed the use of three implants in a maxillary arch, reporting 100% success after 5 years of follow-up. Although these papers report a relatively high survival rate, this approach remains controversial as the loss of one implant leads to failure of the prosthesis, with significant compromise of the outcome. Moreover, the paper with the two implants has very short follow-up and uses a prosthetic concept of a shortened dental arch, having a potential high risk of bias. Hence, one cannot assume that the use of only two implants to support a complete-arch fixed prosthesis is a valid treatment approach.

Twenty-two studies reported on the use of four implants to provide a fixed rehabilitation to the maxilla. Only one study with four implants used parallel placement (Brånemark et al., 1995). This study had a longer follow-up (10 years), used smooth surface implants and

TABLE 4 Risk of bias assessment for non-RCTs—ROBINS-I Tool [In PDF format, this table is best viewed in two-page mode]

First author	Year	Type of study	Confounding	Selection of participans	Classification of interventions
Maló	2005	Retrospective	Moderate	Moderate	Moderate
Degidi	2005	Retrospective	Serious	Serious	Serious
Jemt	2006	Retrospective	Serious	Serious	Serious
Malo	2007	Prospective	Moderate	Moderate	Moderate
Agliardi	2008	Prospective SCoHort	Moderate	Moderate	Moderate
Testori	2008	Prospective	Moderate	Moderate	Moderate
Toljanic	2009	Prospective	Moderate	Moderate	Moderate
Bergqvist	2009	Prospective	Moderate	Moderate	Low
Agliardi	2009	Prospective SCoHort	Moderate	Moderate	Low
Romanos	2009	Retrospective	Moderate	Moderate	Moderate
Degidi	2010	Prospective	Moderate	Moderate	Moderate
Babbush	2011	Retrospective	Moderate	Moderate	Moderate
Malo/de Araújo Nobre	2011	Retrospective	Moderate	Moderate	Moderate
Mertens	2011	Prospective	Moderate	Moderate	Moderate
Cavalli	2012	Retrospective	Moderate	Moderate	Moderate
Maló	2012	Retrospective	Moderate	Moderate	Moderate
Antoun	2012	Retrospective	Moderate	Moderate	Low
Barbier	2012	Prospective	Moderate	Moderate	Low
Mertens	2012	Prospective	Moderate	Moderate	Moderate
Maló	2013	Retrospective	Moderate	Moderate	Moderate
Thor	2014	Retrospective	Moderate	Moderate	Moderate
Maló	2015	Retrospective	Moderate	Moderate	Moderate
Piano	2016	Prospective CoHort	Moderate	Moderate	Moderate
Toljanic	2016	Prospective	Moderate	Moderate	Moderate
Zhang	2016	Prospective	Serious	Moderate	Moderate
Testori	2017	Retrospective	Moderate	Moderate	Moderate
Wentascheck	2017	Retrospective	Moderate	Moderate	Moderate
Brånemark	1995	Retrospective	Moderate	Serious	Moderate
Ferrigno	2002	Prospective	Moderate	Moderate	Moderate
Capelli	2007	Retrospective	Moderate	Moderate	Moderate
Agliardi/Panigati	2010	Prospective CoHort	Moderate	Moderate	Low
Hinze	2010	Prospective CoHort	Moderate	Moderate	Moderate
Puig	2010	Retrospective	Moderate	Moderate	Moderate
Parel	2011	Retrospective	Moderate	Moderate	Moderate
Oliva	2012	Retrospective	Serious	Serious	Moderate
Crespi	2012	Prospective	Moderate	Serious	Moderate
Di	2013	Retrospective	Moderate	Moderate	Moderate
Balshi	2014	Retrospective	Moderate	Moderate	Moderate
Browaeys	2015	Prospective	Moderate	Moderate	Moderate
Babbush	2016	Retrospective	Moderate	Moderate	Moderate
Gherlone	2016	Prospective	Serious	Moderate	Moderate
Najafi	2016	Prospective	Moderate	Moderate	Serious
Sannino	2017	Retrospective	Moderate	Moderate	Moderate
Leimola-Virtanen	1995	Retrospective	Moderate	Moderate	Moderate
Brånemark	1999	Prospective	Moderate	Moderate	Moderate
Eliasson	2000	Retrospective	Moderate	Serious	Moderate
De Bruyn	2001	Prospective	Moderate	Low	Low
Tinsley	2001	Prospective	Serious	Serious	Moderate
Engquist	2002	Prospective	Moderate	Low	Low

(Continues)

TABLE 4 (additional columns)

Deviation from intended interventions	Missing data	Measurements of outcomes	Selection of reported results	Overall	Arch	Number of implants
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	4
Serious	Serious	Serious	Serious	Serious	Maxilla	9
Moderate	Serious	Moderate	Moderate	Serious	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	4
Low	Low	Moderate	Moderate	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	6
Low	Moderate	Low	Low	Low	Maxilla	6
Low	Moderate	Moderate	Low	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Serious	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	7
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	4
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	4
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	4
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	4
Low	Low	Moderate	Moderate	Low	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	4
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	4
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	4
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	6
Moderate	Moderate	Serious	Serious	Serious	Maxilla	8
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Moderate	Moderate	Maxilla	6
Moderate	Moderate	Moderate	Serious	Moderate	Max/Mand	4–6 mx/4–6 md
Moderate	Moderate	Moderate	Moderate	Moderate	Max/Mand	8mx/8md
Serious	Moderate	Moderate	Moderate	Serious	Max/Mand	6mx/4md
Low	Low	Low	Moderate	Low	Max/Mand	4mx/4md
Moderate	Moderate	Moderate	Moderate	Moderate	Max/Mand	4mx/4md
Moderate	Moderate	Moderate	Moderate	Moderate	Max/Mand	4mx/6mx/4md
Moderate	Moderate	Moderate	Moderate	Moderate	Max/Mand	4mx/4md
Moderate	Serious	Serious	Serious	Serious	Max/Mand	3mx/3md
Moderate	Serious	Serious	Serious	Serious	Max/Mand	4mx/4md
Moderate	Moderate	Moderate	Moderate	Moderate	Max/Mand	4mx/4md
Moderate	Moderate	Moderate	Moderate	Moderate	Max/Mand	4mx/4md
Moderate	Moderate	Moderate	Moderate	Moderate	Max/Mand	4mx/4md
Low	Low	Moderate	Moderate	Moderate	Max/Mand	4mx/4md
Moderate	Moderate	Serious	Serious	Serious	Max/Mand	4mx/4md
Moderate	Serious	Serious	Serious	Serious	Max/Mand	4mx/4md
Moderate	Moderate	Moderate	Moderate	Moderate	Max/Mand	4mx/4md
Moderate	Moderate	Moderate	Serious	Serious	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	3
Moderate	Moderate	Moderate	Serious	Serious	Mandible	4
Low	Low	Low	Low	Low	Mandible	3
Moderate	Moderate	Moderate	Serious	Serious	Mandible	5
Moderate	Low	Low	Low	Low	Mandible	4

(Continues)

TABLE 4 (Continued) [In PDF format, this table is best viewed in two-page mode]

First author	Year	Type of study	Confounding	Selection of participans	Classification of interventions
Hatano	2003	Retrospective	Serious	Serious	Moderate
Kronström	2003	Prospective	Moderate	Moderate	Moderate
Maló	2003	Retrospective	Moderate	Moderate	Moderate
van Steenberghe	2004	Prospective	Moderate	Moderate	Moderate
Engquist	2004	Prospective	Moderate	Low	Low
Engquist	2005	Prospective	Moderate	Low	Low
Friberg	2005	Retrospective	Moderate	Moderate	Moderate
Van de Velde	2007	Prospective	Moderate	Moderate	Moderate
Francetti	2008	Prospective	Moderate	Moderate	Moderate
De Bruyn	2008	Prospective	Moderate	Moderate	Moderate
Friberg	2008	Retrospective	Moderate	Moderate	Moderate
Gualini	2009	Retrospective	Moderate	Moderate	Moderate
Agliardi/Clerico	2010	Retrospective	Moderate	Moderate	Low
Schwarz	2010	Prospective	Moderate	Moderate	Moderate
Hatano	2011	Retrospective	Moderate	Moderate	Moderate
Malo/Nobre	2011	Retrospective	Moderate	Moderate	Moderate
Butura	2011	Retrospective	Moderate	Moderate	Moderate
Collaert	2011	Prospective	Moderate	Moderate	Moderate
Cannizzaro	2012	Prospective	Moderate	Moderate	Moderate
Rivaldo	2012	Retrospective	Moderate	Moderate	Moderate
Grandi	2012	Prospective CoHort	Moderate	Moderate	Moderate
Weinstein	2012	Prospective	Moderate	Moderate	Moderate
Galindo	2012	Retrospective	Moderate	Moderate	Moderate
Acocella	2012	Retrospective	Moderate	Moderate	Low
Krennmair	2013	Retrospective	Moderate	Moderate	Moderate
Krennmair	2014	Prospective	Moderate	Moderate	Moderate
Schwarz	2014	Prospective	Moderate	Moderate	Moderate
Romanos	2014	Retrospective	Moderate	Moderate	Moderate
Ayna	2015	Prospective	Moderate	Moderate	Moderate
Meló	2015	Retrospective	Serious	Serious	Moderate
Friberg	2015	Retrospective	Moderate	Moderate	Moderate
Faria	2016	Prospective	Moderate	Moderate	Moderate
Sannino	2016	Retrospective	Moderate	Moderate	Moderate
Calvo-Guirado	2016	Prospective	Low	Moderate	Low
Primo	2018	Prospective	Moderate	Moderate	Moderate

reported a survival rate for the implants of 80.30%, but a restoration survival rate of 100%. This would seem contrary to general opinion that suggests prosthesis failure would result from the loss of even one implant. Recent studies have frequently reported that the loss of one implant in a type of prosthesis supported by four implants does not necessarily mean that the prosthesis is lost. The prosthesis is lost if one of the most distal implants is lost. If one of the anterior implants is lost, then the prosthesis may survive on the remaining three implants, after relining in the area (Maló, de Araújo Nobre, Lopes, Francischone, & Rigolizzo, 2012).

All other 21 papers reported the same implant position configuration that being two anterior implants parallel to each other and the two posterior implants intentionally distally tilted or inclined. This concept has become increasingly popular, with medium to long-term studies being published in recent years (Table 1). This approach seems especially applicable to the edentulous maxilla, due to resorption on the posterior region. Inclining the distal implants reduces the prosthesis cantilever, and the need for grafting. This approach also utilizes a reduced number of implants, which may have advantages and disadvantages. It is not possible, however, to extrapolate from the reviewed literature that the reported survival rates are the result of only the reduction in cantilever dimension. The influence of additional variables cannot be excluded. The inclination of the anterior wall of the maxillary sinus, for example, plays a significant role in defining the implant inclination and therefore the length of cantilever reduction that is achievable (Bedrossian, 2011). In situations where the patient presents with teeth that are planned to be extracted, and a one-piece fixed prosthesis is planned, there

TABLE 4 (additional columns - continued)

Deviation from intended interventions	Missing data	Measurements of outcomes	Selection of reported results	Overall	Arch	Number of implants
Moderate	Serious	Serious	Serious	Serious	Mandible	3
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	3
Moderate	Low	Low	Low	Low	Mandible	4
Low	Low	Low	Low	Low	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	5
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	5
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	5
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	5
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	3
Low	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	5
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	3
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Serious	Serious	Serious	Serious	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	5
Moderate	Moderate	Moderate	Low	Moderate	Mandible	2
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	3
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Serious	Serious	Serious	Serious	Mandible	4
Low	Low	Low	Low	Low	Mandible	5
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	5
Moderate	Moderate	Moderate	Serious	Moderate	Mandible	6
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Serious	Serious	Serious	Serious	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	5
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	4
Low	Low	Low	Low	Low	Mandible	6
Moderate	Moderate	Moderate	Moderate	Moderate	Mandible	3

may be need to reduce vertically the alveolar bone, in order to create space for the restorative components. Such anatomically sound decisions are made during planning of the procedure and therefore influence outcomes. Adding an angled prosthetic component may also influence the mechanical outcome of a one-piece fixed prosthesis.

The use of digital planning can greatly assist in choosing the most appropriate and beneficial implant inclination and therefore defining indications for the use of a tilted implant as opposed to a short implant or a sinus floor elevation graft. Additionally, digital impressions and the use of computer-aided designed and manufactured infrastructures are rapidly growing, allowing for more accurate fit, with an intent to reduce surgical burden, expedite prosthetic delivery and improve long-term results. This approach is being frequently reported in recent publications (Gherlone et al., 2016; Kapos et al., 2009; Papaspyridakos et al., 2017).

One paper (Tallarico et al., 2016) compared use of four and six implants, with 20 patients followed an average of 63.8 months. The implant survival rate was similar, although slightly lower for the group of six implants (95%) than the group with four implants (98.3%). These findings were similar to those reported in a 15-year analysis of fixed rehabilitations for the edentulous maxilla, published by Lambert et al. (2009). These authors concluded that protocols with more than six implants demonstrated a higher survival rate than those with fewer than six implants, although with no statistically significant difference.

For the mandible, although five papers report 98% survival rates on the use of only two implants to support a fixed restoration, they are all from the same author, with a high risk of bias. In contrast, there are a significant number of reports on the use of three implants for a fixed mandibular restoration. The usually higher bone density of the anterior mandible may allow for improved results with this configuration. A recent report by Primo et al. (2018) used three implants to support a fixed prosthesis in edentulous patients, obtaining survival rates for the implants and the prosthesis of 95%. They compared on the same paper immediate vs. conventional loading and had no significant difference. Of interest was that they positioned the distal implants with a DT (distally tilted) configuration, in an attempt to reduce the cantilever, in a few cases. This approach is also used in a previous study by the same group (Rivaldo, Montagner, Nary, da Fontoura Frasca & Brånemark 2012), that proposed it to facilitate the protocols once defined as the "Brånemark Novum" technique (Brånemark et al., 1999), that used parallel placed implants. The distribution of the implants is also emphasized by Oliva et al. (2012), that state that the anterior–posterior distribution of the implants was such as to significantly reduce cantilevers. In the study by Primo et al. (2018), there was no statistically significant association of peri-implant bone loss with the effort arm/resistance arm ratio. Their findings confirm those of Gallucci, Doughtie, Hwang, Fiorellini, and Weber (2009), who did not find a linear correlation between the cantilever length and the number or type of prosthesis-related complications at 5 years of function (Gallucci et al., 2009).

The use of four implants to support a complete mandibular arch fixed prosthesis was by far the most reported on treatment approach, with 41 papers clearly stating the use of four implants with anterior–posterior spread and a screw-retained restoration. Analyzing the results compared to the 10 papers that reported the use of five implants, there was no statistically significant difference. However, most of the papers reporting on five implants utilized smooth surface implants and reported a slightly lower survival rate. The majority of papers discussing on the use of four implants reported utilization of more modern roughened implant surfaces, illustrating an increase in survival rates. A large number of papers reported on use of four implants with immediate loading, beginning in 2003 (Maló et al., 2003) and reviewed in 2014 (Patzelt, Bahat, Reynolds, & Strub, 2014). Anatomic observations and considerations cannot be overlooked when determining clinical applicability of distally tilted or inclined posterior implants.

Immediate loading was reported as the preferred loading approach in the majority of the studies (92 groups of 112 analyzed utilized immediate loading, being 41 in the maxilla, and 52 in the mandible). The majority of the immediate loaded prosthesis were provisional, with acrylic material and screw-retained. There was a clear preference for the use of immediate loading in both maxilla and the mandible, irrespective of the number of implants.

4.3 | Strengths and limitations

This is a comprehensive review and meta-analysis of controlled interventions aimed at rehabilitation of fully edentulous patients with fixed restorations. The strength of this study is the comparison of reports that are clear on the description of the number of implants per arch used. The methodology facilitates comparison of available data where the number of implants was among the main purposes of the studies. Many publications that report on bone grafts and reconstructions have several variable factors in addition to the number of implants. That same issue is found in early publications about osseointegration, where up to 10 implants were placed but not all loaded or utilized, with additional implants placed to cover for failures should they occur. As confidence in osseointegration developed, and microroughened surfaces showed improved results, less implants were placed.

The greatest limitations to this report are the low level of evidence of the majority of the reports (84 non-RCT studies of 93 selected), as well as the relatively short observational period of the majority of the studies with fewer than five implants (median observation period of 5.5 years). The reduced number of descriptive results regarding technical (restoration) and biological complications is also a limitation, as they are expected to increase as time of using the prosthesis progresses. Further, the results reported cannot be evaluated beyond the implant number, to include additional variables, such as the use of angled abutments, surgical and restorative difficulty, one-piece vs. multiple segmented restorations and cantilever lengths. These factors can result from implant position and distribution in addition to implant number and influence outcomes. Based on the parameters of our search, there is inadequate data to compare the marginal bone loss around parallel and distally tilted implants, both for the maxilla as well as for the mandible. However, survival of both implants and prosthesis reported are in excess of 95%. Moreover, our review focused on implant and prosthesis survival, which is not the most challenging method to evaluate implant and patient outcomes.

Regarding the meta-analysis using a random-effects model, and comparing different types of studies, statistical tests of heterogeneity are included in this review, depicted in Figures 2–4. Most show statistically significant heterogeneity, which was anticipated. All meta-analyses with heterogeneity require the same underlying assumption that combining the results is acceptable to obtain an overall interpretation. Moreover, our purpose was not to compare among the treatments tested within each of the published studies. Studies directly comparing fewer than five with five or more implants per arch are not available, so we pulled single arms from the individual studies. Results from the meta-analysis can be interpreted analyzing the figures and are of value to assess the focused question.

4.4 | Comparison with previous systematic reviews

Early publications focusing on fixed rehabilitation of complete edentulous arches report on the mean number of implants per edentulous arch and an overall survival rate. These studies do not report on an exact number of implants per arch. Recent systematic reviews also report on a mean number of implants per arch. Our methodology involved selecting only papers that made clear the exact number of implants placed per arch, as this was our focused question.

The majority of the populations reported (63 out of 112) dealt with four implants per arch. For both the maxilla and the mandible, the most used configuration was two parallel implants placed in the anterior region, where there is usually more bone available, and two distal implants (right and left) with the head of the implant distally tilted, in order to reduce the cantilever and engage adequate available bone. A one-piece complete-arch prosthesis was used with this configuration. This is in accordance with previous systematic reviews (Del Fabbro, Bellini, Romeo, & Francetti, 2012), Patzelt et al., 2014).

As there is usually less bone in the posterior region of the jaws, that configuration also reduces the need for a bone graft and staged implant placement. This allows more patients to be rehabilitated, as it is a less invasive and less expensive procedure, when compared to the grafting alternatives. Although it requires adequate surgical skills to be able to place an inclined implant in the correct 3D position and with good primary stability, it still requires less expertise than a staged bone graft procedure, being much less demanding for the patient regarding overall treatment invasiveness, time and cost. Additionally, a tilted implant approach requires also an advanced prosthodontic expertise and it is more challenging than having to restore parallel placed implants.

Bone remodeling around angled abutments positioned on top of distally tilted implants seems not to be higher, according to Monje, Chan, Suarez, Galindo-Moreno, and Wang (2012). These authors reported in a meta-analysis that marginal bone loss around tilted implants that were splinted to support fixed prostheses was not significantly different from straight implants for the short- or medium-term reviews. However, tilted implants had slightly more marginal bone loss at the medium-term review. There was no evidence that tilted implants are associated with a higher incidence of biomechanic complications. Recent findings related to this approach are being discussed in detail by another systematic review part of this conference (Lin & Eckert, 2018).

Passoni et al. (2014) reported on the relationship between the number of implants and peri-implant disease for full fixed restorations. These authors evaluated 32 patients and 132 implants divided into two groups, five or less and more than five for each arch. Several parameters related to peri-implant disease were observed, and their conclusion was that the use of more than five implants per arch to support a full fixed rehabilitation may increase bone loss and consequently the prevalence of perimplantitis. These findings are in agreement with Corbella, Del Fabbro, Taschieri, De Siena, and Francetti (2011), suggesting that the reduced number of implants, together with motivation of the patient to perform correct hygiene, correct positioning of implants and integrated planning are factors that favor the manufacturing of a suitable prosthesis and increase the chance of maintaining peri-implant health.

Lambert et al. (2009) suggest that six implants are a critical number with respect to the prosthetic survival rate. Our review also shows a high survival rate for studies that use five or more implants, both for the maxilla and the mandible. For the maxilla, the use of six implants seems to be a common protocol, whereas in the mandible, four or five implants were also used frequently.

Gallucci et al. (2016) present the treatment planning variables for maxillary fixed prosthesis, discussing on the utilization of a one-piece vs. a segmented prosthesis. The vast majority of the papers in our review reported on the use of a one-piece prosthesis, splinting all the implants. That approach is required when fewer than five implants are performed. When planning a two, three or four piece segmented restoration for an edentulous arch, the clinician must consider the need to place six to eight implants. Segmented restorations using six to eight implants for support and retention may allow for a better precision on fitting the prosthesis, more accurate laboratory work, and fewer restorative maintenance visits. However, these protocols require optimal bone support and may not be suitable for the majority of the patients, due to lack of adequate bone and/or an increased financial expense. If grafting procedures are indicated, cost and number of interventions for the patient may increase.

Analyzing the data of articles selected for this review, there is a similar use of four and six implants to support a one-piece fixed prosthesis in the maxilla, with immediate loading. In the mandible, there is clear preference to the use of four implants, with immediate loading. The indication of three implants to rehabilitate the mandible with an implant supported complete-arch prosthesis is being reported on with more frequency, with more articles than the classic use of five implants (12 for three implants and 10 for five implants), although with a shorter median follow-up period (3 years for three implants and 4.1 years for five implants), but with similar survival rates (96% and 95%). These results are consistent with the findings of the systematic review performed by Heydecke et al. (2012), and we agree with their conclusions that there is a lack of evidence to determine the optimal number and distribution of implants to support a complete-arch fixed prosthesis, even that our review shows a clear trend to the use of four to six implants. Our findings also are in agreement that there is unclear evidence that the use of more than six implants to support a fixed prosthesis is beneficial to the patients.

4.5 | Implications for researchers and clinicians

As our review included studies that clearly reported the exact number of implants per arch, with at least ten patients and 12 months of follow-up, clinicians can conclude that, at least in the short term, implant survival is high with these treatment protocols. However, many of the studies included in this review, as well as recent publications (Niedermaier et al., 2017), report on patients presenting with compromised dentition, where the treatment planning decision was to extract all teeth and place a one-piece fixed complete prosthesis (hybrid), supported by less than five implants. This modality of treatment is being increasingly performed, and there is a need to prove the long-term outcomes of this approach.

For researchers, this review may identify areas of future interest, as most of the included publications are retrospective or case series studies, with a low level of evidence.

New technologies are being developed and incorporated daily in clinical practices. The use of digital impressions, digital planning, guided surgery and digital printing or milling should provide more accurate and less invasive surgeries, better fitting of prostheses, and hopefully improved patient outcomes.

Recent implant designs, materials and surfaces may further provide higher survival rates, reducing the number of potential complications, for all number of implants used to manage edentulous arches. The use of reduced diameter implants in the anterior region, combined with short and extra-short implants placed in the posterior region, may provide to the clinicians a safer solution as far as reduced cantilever and a minimally invasive surgery, utilizing six implants to support a complete fixed restoration.

Considering that the higher level of evidence is the randomized controlled clinical trial, future research should be focused on this study design so that comparison with early and current less rigorous publications can be more meaningful.

5 | CONCLUSIONS AND RELEVANCE

Evidence from this systematic review and meta-analysis shows that the most reported number of implants for the "fewer than five" group is four for the maxilla, and three and four for the mandible, whereas for the "five or more" implants group, the most reported number of implants was six for the maxilla and five for the mandible. Data analyzed from the included papers suggest that the use of fewer than five implants for rehabilitation of the edentulous maxilla or mandible with a one-piece fixed prosthesis has survival rates (implant and prostheses) similar to those observed using five or more implants per arch, with no statistical significant difference at a $p > 0.005$ and a confidence interval of 95%, with a median follow-up time of 8 years, ranging from 1 to 15 years.

Immediate loading of implants placed in both the maxilla and mandible also provided high survival rates, and most reports utilized immediately positioned screw-retained provisional restorations, substituted by a definitive one-piece rehabilitation after the healing period.

For both maxillary and mandibular rehabilitations, the use of the distal implants with posterior inclination did not seem to affect the overall survival rate for implants and restorations. This was the most reported configuration when using fewer than five implants. When five or more implants were used, the more classic use of parallel implants was reported. Survival rates were similar for both configurations.

It is clear from this review that the placement of fewer than five implants to support a complete-arch fixed restoration allows for high survival rates, for both the maxilla and the mandible. However, additional key variables should ultimately be considered by clinicians when planning treatment for edentulous arches (Gallucci et al., 2016). The number of implants is only one of these variables. The final prosthetic plan should be considered when developing the surgical plan for implant treatment of edentulous arches. Factors to be considered include prosthesis material, one-piece or segmented prostheses, aesthetic factors (lip support, smile line), opposing dentition, available prosthetic space, anatomy of the edentulous ridge (maxilla, mandible, bone volume and quality, anatomic limitations), distribution of implants in the arch, cantilever length, hygiene space, patient preference and compliance.

It should be recognized that a "one-fits-all" approach cannot be identified, and the risks and benefits of choosing the adequate number of implants for each treatment should be evaluated considering all the mentioned variables, to obtain predictable and long-lasting results.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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