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REVIEW ARTICLE

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Clinical performance of immediately placed and immediately loaded single implants in the esthetic zone: A systematic review and meta-analysis

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Abstract

Objectives: The aim of this study was to assess the following PIO question: In adult patients treated with an indication for single tooth extraction in the maxillary esthetic zone (15–25), what is the influence of an immediate implant placement and immediate loading protocol on the clinical performance (primary aim) and esthetic outcomes (secondary aim) focusing on investigations published after 2010.

Material and Methods: An electronic search in Medline (PubMed), the Cochrane Central Register of Controlled Trials, and EMBASE databases up to April 2022 was performed to identify clinical studies investigating the outcome of single implants subjected to immediate placement with immediate restoration/loading (Type 1A).

Results: Sixty-three studies (10 randomized controlled trials, 28 prospective and 25 retrospective cohort studies) were included with a follow-up ranging from 12 to 96 months. One thousand nine hundred sixty-one implants reported survival rates of 99.2 (98.6–99.5) % at 1 year, 97.5 (95.9–98.4) % after 3 years, and 95.8 (93.3–97.4) % after 5 years; 1064 immediately loaded restorations presented survival rates of 98.9 (97.8–99.5) % after 1 year, 96.8 (93.6–98.4) % after 2 years, and 94.8 (89.6–97.4) % after 5 years. Comparing baseline to 12-month data using the Hedges' g effect size (95% CI), papilla height presented an overall effect size of −0.71 (−1.25, −0.1) mm, mid-facial recession change of −0.15 (−0.66, 0.36) mm, and a 0.82 (0.37, 1.28) gain in PES.

Conclusions: Immediate implant placement and immediate loading can be considered a predictable and safe treatment option for single maxillary anterior restorations with adequate survival rates and favorable esthetics outcomes for up to 5 years.

KEYWORDS
dental implants, esthetic outcomes, immediate, papilla index, peri-implant soft tissue, pink esthetic score, provisional, white esthetic score

1 | INTRODUCTION

Although partial edentulism is decreasing among industrialized countries due to improvements in oral health, this condition is still prevalent as a result of endodontic failures, trauma, and other causes (Schneider et al., 2017). Additionally, lifestyles are currently strongly influenced by esthetics; in this regard, anterior tooth loss and its associated esthetic impact can affect patients' satisfaction with their dentition in daily life (Al-Omiri et al., 2009).

Immediate implant placement and immediate loading/restoration (Type 1A) has become a popular and attractive treatment option for both dentists and patients. This implant protocol not only reduces the treatment time and clinical morbidity but also preserves the peri-implant mucosal tissue after tooth extraction, resulting in the best possible esthetic result (van Nimwegen et al., 2016; Yan et al., 2016). With increased publications reporting such interventions, Type 1A implant treatment has become a clinically documented protocol (Gallucci et al., 2018). With progressive advances in implant dentistry and high survival and success rates of immediate implants in recent years, there has been increased interest in esthetic evaluation on immediately placed and immediately loaded/restored implants (Mangano et al., 2017; Slagter et al., 2021; Vidigal et al., 2017). The demand for the optimal esthetic results observed when implementing the Type 1A protocol has increased, especially in the maxillary anterior area (Mangano et al., 2017; Slagter et al., 2021; Vidigal et al., 2017).

Immediate implant placement (Type 1) is the treatment of choice for carefully selected failing single teeth cases since local alveolar anatomy following tooth extraction has a large impact on the soft and hard tissue behavior around the future implant (Buser et al., 2017; Gallucci et al., 2018) and therefore in esthetics. Although the predictability of this approach has been widely described, to date, there is no review that evaluates the influence of the different treatment modalities on the esthetic outcomes and clinical performance of single implant treatments in the maxillary esthetic zone.

The primary aim of the present systematic review was to evaluate the clinical performance by means of implant and prosthetic survival and complication rates, and the secondary outcome was to assess the crestal bone loss and esthetic outcomes by means of esthetic indices of implants and their supported restorations inserted with Type 1A implant placement and loading (immediate placement + immediate restoration/loading) in the maxillary anterior zone, focusing on investigations published after 2010, answering the following PIO question: In adult patients treated with on indication for single tooth extraction in the maxillary esthetic zone (15–25), what is the influence of an immediate implant placement and immediate loading protocol on the clinical performance and esthetic outcomes.

2 | MATERIALS AND METHODS

2.1 | Study protocol

The present systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Page et al., 2021) and the Cochrane Handbook for Systematic Reviews of Interventions (Deeks et al., 2021). The protocol and the review were designed according to the PIO (Population, Intervention, Outcome) model:

- Population: Adult patients with indication for single tooth extraction and immediate single implant and immediate loaded implant-supported crown protocol in the esthetic anterior maxilla 15–25 (FDI).
- Intervention or exposure: Immediate implant placement and immediate loading of single implants using modern dental implants after 2010 with no particular surgical or restorative procedure.
- Outcome: Clinical performance as primary outcome (Implant and prosthetic survival rates), and as secondary aim, crestal bone loss, esthetic outcomes by means of esthetic indices (papilla height, papilla index and heights), midfacial/buccal recession in soft tissue level, pink esthetic score (PES) (Belser et al., 2009), pink esthetic score (Fürhauser et al., 2005), white esthetic score (WES).

Therefore, the PIO question was as follows: In adult patients treated with an indication for single tooth extraction in the maxillary esthetic zone (15–25), what is the influence of an immediate implant placement and immediate loading protocol on the clinical performance and esthetic outcomes.

In the present review, there was no comparison with other loading and placement protocols. Subgroup analyses were made with respect to flap versus flapless implant placement, screw-retained versus cement-retained restorations.

2.2 | Eligibility criteria

2.2.1 | Inclusion criteria

- Clinical studies of single implants and implant-supported crowns using an immediate implant placement and immediate loading protocol in the anterior maxilla 15–25 (FDI), including objective esthetic outcomes, implant information, surgical procedures, and the restorative procedure.
- Studies published after 2010 will only include modern surface implants and updated protocols. Older studies may include smooth surface implants and older protocols and as such introduce a research bias. As we cannot differentiate between the implant surfaces and the followed protocols in the older studies, we have chosen for this approach as we expect that these studies will provide us with the information we seek.
- Randomized and controlled clinical trials, cross-sectional studies, cohort studies, case–control studies, case series including at least 10 participants.
- Studies including clearly documented clinical procedures (implant design, surface, implant material; surgical procedures: GBR, soft tissue grafting, extraction socket grafting, no augmentation procedures; flapless, flap implant surgery; restorative procedures:

type of provisional, type of definitive crown including abutment types and material).
- Studies including clearly documented objective esthetic outcomes on esthetic indices.
- Minimum follow-up period of 12 months.
- Publications written in English, German, or Spanish.

2.2.2 | Exclusion criteria

- Review articles, chart reviews, case reports, and/or questionnaires.
- In vitro or animal studies.
- Implants supporting full-arch restorations or partial restorations replacing more than one missing tooth and implants supporting removable prostheses.
- Fully edentulous patients, implants placed in irradiated bone or alveolar clefts.
- Studies including soft tissue, peri-implant, and/or esthetic evaluations that do not use objective esthetic outcomes on esthetic indexes in implant dentistry.
- Insufficient documentation regarding implant placement and loading, objective clinical outcomes, esthetic outcome assessments, implant design, surgical procedures, and/or the restorative procedure.
- Inability to separate data for sites in the esthetic zone from posterior and mandibular sites or across intervention groups.

2.3 | Search strategy

An electronic search from January 1, 2010, to April 1, 2022, in three databases – National Library of Medicine (MEDLINE [PubMed]) (applying Textwords), the Cochrane Central Register of Controlled Trials (CENTRAL) (applying only trials, there were no reviews), and EMBASE (Elsevier) – was performed without applying any additional time or language restrictions and with the assistance of a medical information specialist at the Medicine University Library of the University of Bern. The search strategy is shown in Table 1. In addition, a literature hand searches from January 1, 2010, to April 1, 2022, was performed. References of the included studies and previous systematic reviews on loading protocols for single implants (Zhou et al., 2021) were screened. Reviewer agreement during the study selection process was estimated using Cohen's kappa statistics (*k*-score).

2.4 | Study selection process and data collection

References were imported to a reference manager software program (EndNote, Thomson Reuters), and duplicates were removed via the Leads method. Following this, a Research Information Systems (RIS) file with the obtained references was imported to Covidence (Veritas Health Innovation, Melbourne, Australia; available at www.covidence.org) and two independently calibrated reviewers (J.G.W. and P.M-M.) performed title, abstract, and full-text screening. Disagreement regarding inclusion was resolved by reviewer discussion. If a comparison arm or multiple cohorts were identified in the same study, data from Type 1A implant placement and loading protocol from each group were recorded separately. If an article reported longitudinal data from the same cohort, information from the longest follow-up was included.

2.5 | Data items

Data extracted and collected from each included article were recorded in an Excel spreadsheet (Version 15.17, Microsoft) by four calibrated reviewers (J.W., P.M-M., B.O. and M.A.), and any potential disagreement was resolved by consensus. The following items were recorded and analyzed: author, year of publication, number of participants, sex, age, follow-up, number of dropouts, number of implants, implant design/surface, surgical procedure (bone and soft tissue augmentation procedure), restorative procedure (provisional restoration, definitive restoration material), biological complications, technical complications, and esthetic index information.

2.6 | Summary measures, synthesis of results, data, and statistical analysis

In the present systematic review, the primary outcome was to evaluate the clinical performance by means of implant and restoration failure and survival rates as well as the rates of surgical, technical, and biological complications.

Regarding clinical performance subgroup analyses were made according to the following:

- Implant design: tapered versus parallel and active versus passive threads, surface, implant material.
- Surgical procedures: GBR versus soft tissue grafting versus extraction socket grafting versus no augmentation procedures; flapless versus flap implant surgery.
- Restorative procedures: Screw retained versus cement retained type of provisional, type of definitive crown.

The secondary outcome was to assess the esthetic outcomes of immediate implant placement and immediate loading of single implants regarding the esthetic indices (Papilla height, papilla index), midfacial/buccal recession in soft tissue level, pink esthetic score (PES) (Belser et al., 2009), pink esthetic score (Fürhauser et al., 2005), white esthetic score (WES) following a recent review of esthetic assessments in implant dentistry (Cosyn et al., 2017). For comparability of PES Belser and PES Fürhauser, mean and standard deviation of the two scores were transformed into percentages of the maximum of the score (PES Belser: maximum 10, PES Fürhauser maximum 14).

TABLE 1 Systematic search strategy for the focus question.

Focused question	In adult patients with indication for single tooth extraction in the maxillary esthetic zone (15–25), what is the influence of an immediate implant placement and immediate loading protocol on the clinical performance and esthetic outcomes	
PIO	Population	Adult patients with indication for single tooth extraction and immediate single implant and immediate loaded implant-supported crown protocol in the esthetic anterior maxilla 15–25 (FDI).
	Intervention	Immediate implant placement and immediate loading of single implants using modern dental implants after 2010 with different surgical and restorative procedures.
	Outcome	Clinical performance and esthetic outcomes: Implant and prosthetic survival rates, papilla heights, crestal bone loss, Esthetic indices (Papilla height, papilla index), midfacial/buccal recession in soft tissue level, pink esthetic score (PES) (Belser et al., 2009), pink esthetic score (Fürhauser et al., 2005), white esthetic score (WES), implant and prosthetic survival rates, papilla heights, crestal bone loss.
Search Strategy	Pubmed	((“dental implantation, endosseous”[MeSH Terms] OR “dental implants”[MeSH Terms] OR “implantation*”[Text Word] OR “implant”[Text Word] OR “implants”[Text Word]) AND (“dental prosthesis, implant supported”[MeSH Terms] OR “crown*”[Text Word] OR “single crown”[Text Word] OR “single unit*”[Text Word]) AND (“immediate implant*”[Text Word] OR “immediate implant placement”[Text Word] OR “immediate placement*”[Text Word] OR “immediate”[Text Word] OR “fresh extraction socket*”[Text Word] OR “immediate extraction socket*”[Text Word]) AND (“immediate dental implant loading”[MeSH Terms] OR “immediate”[Text Word]) AND (“esthetics”[MeSH Terms] OR “esthetic*”[Text Word] OR “aesthetic*”[Text Word] OR “esthetic indices”[Text Word] OR “esthetic index”[Text Word] OR “esthetic assessment*”[Text Word] OR “esthetic outcome*”[Text Word] OR “white esthetic score*”[Text Word] OR “wes”[Text Word] OR “pink esthetic score*”[Text Word] OR “pes”[Text Word] OR “complex esthetic index”[Text Word] OR “copenhagen index score”[Text Word] OR “recession*”[Text Word] OR “mucosal recession*”[Text Word] OR “midfacial recession*”[Text Word] OR “mucosal change*”[Text Word] OR “soft tissue*”[Text Word])) AND (english[Filter])
	Embase	(implant* OR “implant”/exp OR “endosseous implant”/exp OR “tooth implant”/exp OR “tooth implantation”/exp) AND (“implant-supported denture”/exp OR “tooth crown”/exp OR crown* OR “single crown*” OR “single unit*”) AND (“immediate implant*” OR “immediate implant placement*” OR “immediate placement*” OR “immediate” OR “fresh extraction socket*” OR “immediate extraction socket*” OR immediate) AND (“esthetics”/exp OR esthetic* OR aesthetic* OR “esthetic indices” OR “aesthetic indices” OR “esthetic index” OR “aesthetic index” OR “esthetic assessment*” OR “aesthetic assessment*” OR “esthetic outcome*” OR “aesthetic outcome*” OR “white esthetic score*” OR wes OR “pink esthetic score*” OR pes OR “implant crown esthetic index” OR “implant crown esthetic indices” OR “complex esthetic index” OR “copenhagen index score*” OR recession* OR “mucosal recession*” OR “midfacial recession*” OR “mucosal change*” OR “soft tissue*”) AND [english]/lim
	Cochrane	[Dental Implantation, Endosseous] OR [Dental Implants] OR (implantation* OR implant OR implant*) AND [Dental Prosthesis, Implant-Supported] OR (crown* OR “single crown*” OR “single unit*”) AND (“immediate implant*” OR “immediate implant placement” OR “immediate placement*” OR “immediate” OR “fresh extraction socket*” OR “immediate extraction socket*”) AND [Immediate Dental Implant Loading] AND [Esthetics] OR (Esthetic* OR aesthetic* OR “esthetic indices” OR “esthetic index” OR “esthetic assessment*” OR “esthetic outcome*” OR “white esthetic score*” OR wes OR “pink esthetic score*” OR pes OR “implant crown esthetic index” OR “implant crown esthetic indices” OR “complex esthetic index” OR “copenhagen index score” OR recession* OR “mucosal recession*” OR “midfacial recession*” OR “mucosal change*” OR “soft tissue*”)
Database Search	MEDLINE (PubMed), Embase, and Cochrane.	

Implant placement and implant loading were assessed following definitions from the 6th Consensus Conference of the International Team for Implantology (Gallucci et al., 2018): Type 1 implant placement; immediate implant placement: dental implants are placed in the fresh socket on the same day of tooth extraction (Chen et al., 2004; Chen & Buser, 2009; Hämmerle et al., 2004). Type A implant loading; immediate loading: dental implants are connected to the prosthesis within 1 week of implant placement. Type 1A: immediate placement with immediate restoration/loading (Gallucci et al., 2018).

Surgical and implant complications were assessed individually between studies according to each study's own assessment, definition, and description. Biological complications were evaluated based on the specific assessment of each study following the Lang criteria (Lang et al., 2000). Technical complications were assessed following the definitions reported at the 4th Consensus Conference of the International Team of Implantology (Salvi & Bragger, 2009).

Failure and survival rates of implants and restorations, as well as surgical, technical, and biological complications rates, were estimated assuming Poisson distributed failures. The Poisson

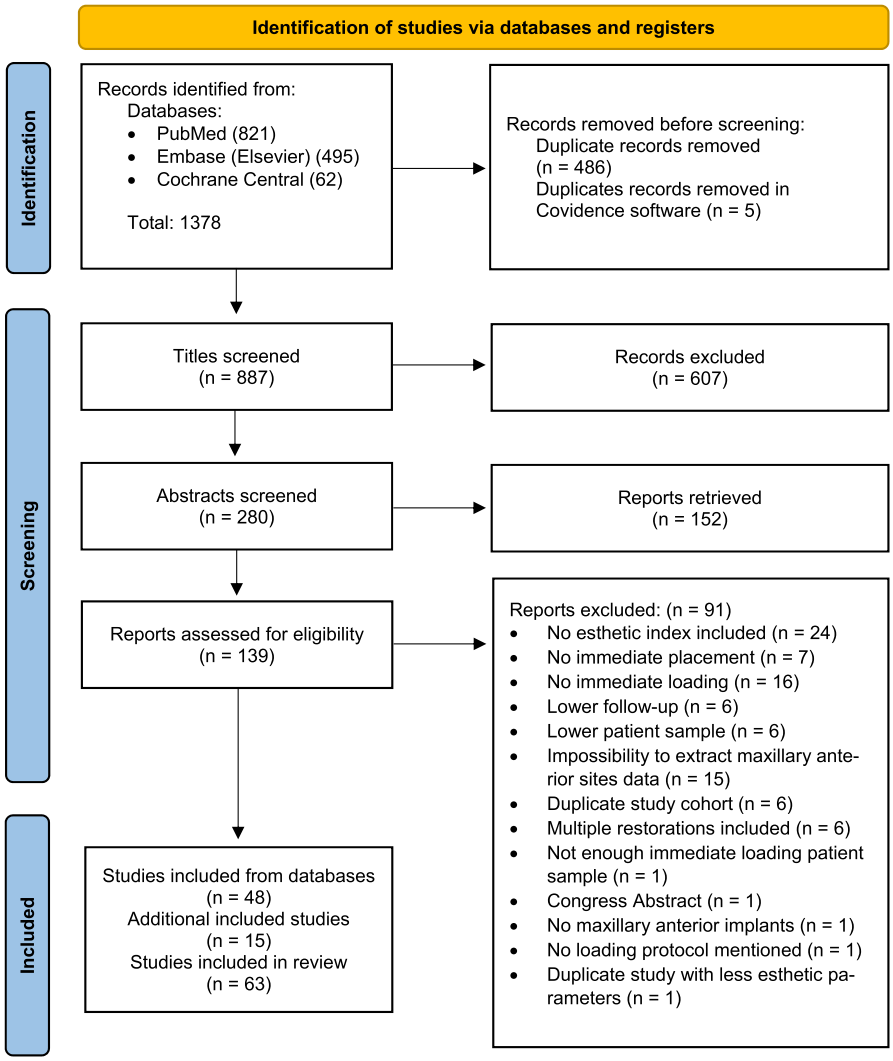

FIGURE 1 Flowchart.

distribution describes the probability of a given number of events during a fixed period of time assuming that events occur independently and that the mean event rate is constant. Overall failure, survival, and complication rates were estimated using a random-effects Poisson regression. For the estimation of failure, survival, technical, and biological complication rates, the cumulated follow-up time of implants or restorations was taken as the exposure variable. To estimate the surgical complication rates of implants and restorations, the total number implants or restorations were taken as the exposure variable. A random-effects Poisson regression was used to analyze whether restoration survival rates were dependent on the retention type (screw/cement). The same method was applied to estimate the effect of the surgical complication rate of implants on the rate of technical and biological complications of restorations.

The secondary outcome was to assess the esthetic outcomes by using weighted means of papilla height, papilla index, midfacial/buccal recession at the soft tissue level, and PES (%) and WES were estimated with a random effects model using a restricted maximum likelihood estimator for inter-study variance (REML). Since esthetic scores of studies were reported for baseline and mixed follow-up times, meta-analysis regression adjusted for time was used to compare the overall mean esthetic score of subgroups (flap vs. no flap, type of implant (parallel-walled/tapered walled), implementation of a soft tissue procedure, and the implant connection were extracted). Based on baseline and follow-up data after 12 months, Hedges' *g* effect sizes (ES) were calculated for those esthetic outcomes with sufficient data for a baseline versus follow-up comparison (Goulet-Pelletier & Cousineau, 2018). Hedges' *g* is calculated by multiplying Cohen's *d* by a so-called correction factor, which is based on the number of observations and the Gamma function. Since cross-measurement correlations between baseline and follow-up data of the studies were not known, Hedges' *g* was calculated assuming independent data. A random effects model (REML) was used to estimate overall ES and 95% confidence intervals. All *p*-values are two-sided with a significance threshold of .05. Stata/IC 16.1 for Unix was used for statistical analysis.

2.7 | Risk of bias

To assess the methodological quality of the selected studies, the ROB 2 risk of bias tool for randomized controlled trials (RCTs) and

the Newcastle-Ottawa-Scale (NOS) (Wells et al., 2013) for observational and case–control studies were used, and the evaluation was performed by three independent and calibrated reviewers (P.M-M., B.O. and M.A.). The ROB 2 risk of bias tool is a domain-based tool in which critical assessments are evaluated independently for each domain. This tool is based on five domains that can be qualified as "Low" or "High" risk of bias or can express "some concerns". The NOS is a quality assessment tool for nonrandomized trials, in which included studies can receive a maximum of 9 stars. A classification of 7–9 points corresponds to a low risk of bias, 5–6 points to a medium risk of bias, and fewer than 5 points to a high risk of bias.

3 | RESULTS

3.1 | Search results

The initial electronic search of the three databases resulted in a total of 1378 references, from which 486 duplicate records were removed via EndNote and 5 using the Covidence software. A total of 887 potential references were selected, of which the authors screened 280 abstracts; from these, 139 references were included for full-text evaluation. Following this, a total of 48 articles were included and 91 were excluded based on the selection criteria. In addition, the hand search identified 15 additional studies, yielding a final total of 63 articles included in the present systematic review (Figure 1 and Table S1).

Regarding inter-reviewer agreement, Cohen's kappa statistic ± standard deviation (SD) range was: 0.567 ± 0.030 (95% confidence interval [CI]: 0.626–0.508) (moderate agreement) for title selection, 0.978 ± 0.059 (95% confidence interval CI: 1.095–0.861) for abstract selection (excellent agreement), and 0.799 ± 0.798 (95% CI: 0.961–0.635) (excellent agreement) for full-text assessment.

3.2 | Description of included studies

Among the included references, 63 studies (10 randomized controlled trials, 28 prospective cohort, and 25 retrospective cohort studies) were included with follow-up periods that ranged from 12 to 96 months (Table 2a–f).

Although including a greater number of implants can provide stronger evidence due the representativity of the sample, overall, the included studies showed a substantial between-study heterogeneity, for most of the analysis the fraction of variance that is due to heterogeneity (I^2) is over 50%. Therefore, a supplement analysis was performed only focusing on the RCT studies.

3.3 | Risk of bias within studies

The risk of bias for the included randomized clinical trial showed eight trials with low risk and one with some concerns. Considering the quality assessment of the included cohort studies reported nine stars in three studies, eight stars in six, seven stars in five, six stars in 10, five stars in 20, four stars in eight, and finally three stars in two studies (Table 3a,b).

3.4 | Implants and restoration survival meta-analysis

Focusing on implant survival, data extracted from 61 studies (encompassing 1961 implants) were obtained. A detailed overview of the individual studies is given in Table 4. A total of 35 failures occurred, with survival rates of 99.2 (98.6–99.5) % at 1 year, 97.5 (95.9–98.4) % after 3 years, and 95.8 (93.3–97.4) % after 5 years (Table 4 and Table S2). Restoration survival data were obtained from 35 studies, covering 1064 immediately loaded restorations. Failure rates per study are presented in Table 5. The overall restoration survival rates were 98.9 (97.8–99.5) % after 1 year, 96.8 (93.6–98.4) % after 2 years, and 94.8 (89.6–97.4) % after 5 years (Table 5). Restoration survival rates on study type are displayed in Tables S3 and S4. Data assessing the influence of the individual retention type – screw versus cement retention – with respect to restoration survival were analyzed; both retention types presented similar survival rates calculated up to 5 years; ranged from 99.0% to 95.0% for screw-retained restorations and from 98.7% to 93.4% for cement-retained (Table 6).

3.5 | Surgical complications of implants, biological and technical complications of restorations

Of 63 included articles, 38 reported any complication, and therefore the analysis and sub-analysis were based on these studies follow-up and related information. An overview of reported surgical complications in the included studies is given in Table 7. The estimated surgical complication rate calculated per 100 implants (95% CI [confidence interval]) of the 1281 immediately placed implants reported across 38 studies was 5.86 (3.40–10.11) %. Focusing on the included studies, an overview of technical and biological complications is presented in Tables 8 and 9. According to random-effects Poisson regression analysis, individual complication rates per 100 restorations were estimated (95% CI) to be 3.27 (1.51–7.07) technical and 2.18 (0.91–5.23) biological complications per restoration year. To evaluate the influence of surgical complications on the rate of technical and biological complications, an incidence rate analysis was performed. The outcome was that neither complication rate (technical or biological) was significantly influenced by surgical complications (Tables S4–S6).

3.6 | Esthetic outcome meta-analysis

Esthetic outcomes were documented using the retrieved data including the following indices: papilla height (mm), papilla index,

TABLE 2A General characteristics of the included studies.

Author (year)	Country	Type of study	Clinical settting	Total number of patients	Patients included for assessment	Gender	Patients age (SD)	Follow-up (SD) in months
Arora et al. (2017)	Australia	Prospective study	Private practice	20	20	13 females, 3 males	44.7 (12.7)	37 (14)
Arora and Ivanovski (2018)	Australia	Retrospective study	University	30	30	21 females, 9 males	NM	47 (15)
Barone et al. (2016)	Italy	Prospective study	NM	32	30	21 females, 16 males	40.1 (13.3)	84
Bonnet et al. (2018)	France	Retrospective study	Private practice	39	39	27 females, 16 males	37.6	12
Bruno et al. (2014)	Intaly	Prospective study	Private practice	28	12	11 females, 12 males	59.9 (12.2)	12
Cabello et al. (2013)	Spain	Prospective study	Private practice	14	14	7 females, 7 males	52	12
Cardaropoli et al. (2015)	Italy	Prospective study	Private practice	26	26	14 females, 12 males	42.35 (9.41)	12
Cardaropoli et al. (2019)	Italy	Prospective study	Private practice	20	20	13 females, 7 males	58.5 (11.03)	12
Chan et al. (2019)	USA	RCT	University	20	18	8 females, 10 males	60.4 (12)	12
Cooper et al. (2014)	USA	Prospective study	University	55	45	33 females, 22 males	45 (14)	60
Cosyn et al. (2011)	Belgium	RCT	University	32	25	16 females, 14 males	54	36
Cosyn et al. (2013)	Belgium	Retrospective study	University	28	28	15 females, 13 males	51 (15)	33 (8)
Cosyn et al. (2016)	Belgium	Prospective study	Private practice	22	17	10 females, 12 males	50	60
Cristalli et al. (2015)	Italy	Prospective study	Private practice	60	60	15 females, 9 males	47.27 (8.25)	48
Crespi et al. (2018)	Italy	RCT	MN	28	24	15 females, 15 males	55.6	12
D'Avenia et al. (2019)	Italy	Retrospective study	University	20	20	7 females, 13 males	50.42 (11.35)	16
Degidi et al. (2014)	Italy	RCT	Private practice	91	53	NM	40.1 (12.5) 37.7 (14.3)	24
Esposito et al. (2015)	Italy	RCT	Private practice	106	54	32 females, 22 males	48	12
Felice et al. (2015)	Italy	RCT	Private practice	50	25	13 females, 12 males	51.32	12
Fürhauser et al. (2016)	Austria	Prospective study	Academy	77	77	46 females, 31 males	48.8 (16.1)	60
Ganeles et al. (2017)	USA	Prospective study	Private practice	15	11	6 females, 9 males	68.33 (14.4)	24
Guarnieri et al. (2016)	Italy	Retrospective study	Private practice	25	25	5 females, 7 males	42	36
Groenendijk et al. (2020)	The Netherland	Prospective study	Private practice	100	98	57 females, 41 males	45.8	12
Hartlev et al. (2014)	Denmark	Prospective study	University	68	54	21 females, 33 males	43	33
Hassani et al. (2021)	Iran	Retrospective study	University	20	20	13 females, 7 males	38.1	12
Kan et al. (2011)	USA	Prospective study	University	35	35	NM	36.8	48
Khzam et al. (2014)	Australia	Retrospective study	University	13	13	9 females, 4 males	44.7 (18.7)	23.2 (7.6)
Kniha et al. (2017)	Germany	Prospective study	Hopsital	16	16	NM	55	12
Kolerman et al. (2016)	Israel	Retrospective study	University	34	34	20 females, 14 males	52.68 (14.35)	12–48
Kolerman et al. (2017)	Israel	Retrospective study	University	39	39	23 females, 16 males	47.51 (18.09)	44.82 (28)
Lombardo et al. (2016)	Italy	Retrospective study	University	16	16	11 females, 5 males	44	23.3 (14.8)
Ma et al. (2019)	New Zeeland	Prospective study	University	27	16	12 females, 4 males	NM	60
Malchiodi et al. (2013)	Italy	Prospective study	University	58	58	26 females, 32 males	39.9	36
Mangano et al. (2012)	Italy	Prospective study	NM	26	26	8 females, 18 males	48.7	24

TABLE 2A (Continued)

Author (year)	Country	Type of study	Clinical settting	Total number of patients	Patients included for assessment	Gender	Patients age (SD)	Follow-up (SD) in months
Mangano et al. (2013)	Italy	Retrospective study	NM	40	40	8 females, 10 males	44.9	31.09 (5.27)
Mangano et al. (2017)	Italy and Brazil	Retrospective study	Private practice	103	103	27 females, 15 males	46.5 (15.1)	36
Migliorati et al. (2015)	Italy	Prospective study	University	50	48	25 females, 23 males	47.5	24
Noelken et al. (2011)	Germany	Retrospective study	University	16	16	11 females, 5 males	43	22
Noelken et al. (2018) (2)	Germany	Retrospective study	University	26	26	12 females, 14 males	48.4	45 (23)
Östman et al. (2020)	USA	Prospective study	Private practice	19	19	11 females, 8 males	NM	19
Paul and Held (2012)	Switzerland	Retrospective study	NM	28	26	16 females, 10 males	44.8	40.8
Pieri et al. (2011)	Italy	RCT	University	40	38	23 females, 15 males	45.8 46.6	12
Puisys et al. (2022)	Lithuania	RCT	University	52	52	15 females, 10 males	45.8 (13.63)	12
Raes et al. (2018)	Belgium	Prospective study	Private practice	39	29	6 females, 10 males	45	96
da Rosa et al. (2014)	Brazil	Prospective study	Private practice	24	18	8 females, 10 males	52.4	58.56 (8.19)
Ross et al. (2014)	USA	Retrospective study	Private practice	47	47	28 females, 19 males	47.4	60
Saedi Germi et al. (2020)	Iran	Retrospective study	Private practice	18	18	10 females, 8 males	NM	12
Sicilia-Felechosa et al. (2020)	Spain	Retrospective study	University	40	40	23 females, 17 males	58.7	41.28
Slagter et al. (2021)	The Netherlands	Retrospective study	University	40	40	15 females, 5 males	39 (16.9)	60
Spinato et al. (2012)	Italy	Retrospective study	NM	41	41	30 females, 11 males	42.5	32
Stoupel et al. (2016)	USA	RCT	University	39	39	25 females, 14 males	54 46	12
Sun et al. (2020)	China	Prospective study	Hospital	30	30	23 females, 37males	NM	24
Takeshita et al. (2015)	Japan	Retrospective study	Private practice	18	18	NM	48	18
Tian et al. (2019)	China	Prospective study	Hospital	30	27	14 females, 16 males	34.6 (12)	12
Tortamano et al. (2010)	Brazil	Prospective study	University	12	12	3 females, 10 males	NM	18
Tsuda et al. (2011)	USA	Retrospective study	University	10	10	6 females, 4 males	48	12
Valentini et al. (2010)	France	Retrospective study	NM	90	40	NM	NM	12
van Nimwegen et al. (2016)	The Netherlands	Retrospective study	Private practice	64	51	23 females, 26 males	50	48
van Nimwegen et al. (2018)	The Netherlands	RCT	University	60	50	17 females, 13 males	45.5 (15.5)	12
Vidigal et al. (2017)	Brazil	Retrospective study	NM	53	53	31 females, 22 males	46	51
Yang et al. (2019)	China	Prospective study	University	40	40	18 females, 22 males	38.31 (11.23)	12
Yoshino et al. (2014)	USA	Prospective study	University	20	20	13 females, 6 males	52.6	12
Zuiderveld et al. (2018)	The Netherlands	Prospective study	University	60	58	32 females, 28 males	45.5 (15.5) 47.8 (15.3)	12

Abbreviations: NM, not mentioned; RCT, randomized clinical trial; SD, standard deviation.

TABLE 2B Implant characteristics of the included studies.

Author (year)	Total number of implants	Implants included for assessment	Implant failed	Implant material	Implant manufacturer	Implant type	Implant surface	Implant connection type
Arora and Ivanovski (2018)	20	20	0	1	Osseospeed Dentsply (AstraTech)	1	4	6
Arora et al. (2017)	30	30	0	1	Osseospeed Dentsply (AstraTech)	1	4	6
Barone et al. (2016)	37	35	2	1	Premium/Khono, Sweden & Martina	1	8	2
Bonnet et al. (2018)	39	39	0	1	Nobel Replace/Nobel Actuve	1/2	3	7/3
Bruno et al. (2014)	36	17	0	1	NobelActive, NobelReplace Select, NobelPerfect	1/2	3	7/3
Cabello et al. (2013)	14	14	0	1	Straumann	1	1	9/10
Cardaropoli et al. (2015)	26	26	0	1	T3 Biomet 3i	3	5	2
Cardaropoli et al. (2019)	20	20	0	1	Straumann BLT	1	2	9
Chan et al. (2019)	20	18	2	1	IS II active, Neobiotech	2	1	2
Cooper et al. (2014)	55	52	3	1	OsseoSpeed. Dentsply Implants.	1	4	6
Cosyn et al. (2011)	32	25	1	1	Nobel Replace tapared	2	3	2
Cosyn et al. (2013)	28	26	3	1	Nobel Replace tapared	2	3	7
Cosyn et al. (2016)	22	17	NM	1	Nobel Replace tapared	2	3	7
Crespi et al. (2018)	30	30	0	1	Outlink, Sweden & Martin	2	7	1
Cristalli et al. (2015)	23	23	2	1	Nobel Active	2	3	3
D'Avenia et al. (2019)	20	20	NM	1	Nobel Active	2	3	3
Degidi et al. (2014)	53	53	0	1	ANKYLOS, DENTSPLY	2	1	4
Esposito et al. (2015)	54	54	2	1	V3 Mis Implants	2	11	3
Felice et al. (2015)	50	50	2	1	MegaGen implant	1	10	3
Fürhauser et al. (2016)	77	77	0	1	XiVE S Plus	2	9	3
Ganeles et al. (2017)	15	11	0	1	75 Nobel Replace; 2 Astra Osseospeed	1/2	3/4	6
Guarnieri et al. (2016)	12	12	0	1	Laser-lok, Biohorizon	2	13	2
Groenendijk et al. (2020)	98	98	0	1	Nobel Active	2	3	3
Hartlev et al. (2014)	68	54	1	1	Nobel replace select	2	3	7
Hassani et al. (2021)	20	20	0	1	Superline. Dentium	1	1	2
Kan et al. (2011)	35	35	0	1	Nobel replace	2	3	7
Khzam et al. (2014)	15	15	0	1	Nobel Active	2	3	3
Kniha et al. (2017)	16	16	0	2	Straumann PURE Ceramic Implant	1	12	8
Kolerman et al. (2016)	34	34	0	1	Seven MIS Implants	2	1	2
Kolerman et al. (2017)	39	39	1	1	Lans or Seven, MIS Implants	2	11	2
Lombardo et al. (2016)	21	21	1	1	Bicon dental implant	1	14	5
Ma et al. (2019)	28	17	2	1	Co-Axis 12d, Southern Implants	1	6	1
Malchiodi et al. (2013)	64	64	0	1	NM	2		NM
Mangano et al. (2012)	21	21	1	1	Bicon dental implant	1	14	5

TABLE 2B (Continued)

Author (year)	Total number of implants	Implants included for assessment	Implant failed	Implant material	Implant manufacturer	Implant type	Implant surface	Implant connection type
Mangano et al. (2013)	26	26	0	1	Leone implant system	1	15	4
Mangano et al. (2017)	40	22	0	1	Leone implant system	1	15	4
Migliorati et al. (2015)	48	47	0	1	Straumann.BLTI.	2	2	9
Noelken et al. (2011)	18	18	0	1	Nobel Biocare. Nobel Perfect (3) Nobel perfect groovy (15)	2	2	3
Noelken et al. (2018) (2)	26	26	0	1	AstraTech	1	4	6
Östman et al. (2020)	19	19	0	1	Southerm Implants of North America	3	6	1
Paul and Held (2012)	33	31	0	1	Nobel Biocare. Nobel Perfect.	2	3	6
Pieri et al. (2011)	38	37	1	1	Samo Smiler Implants, Biospark	2	5	2
Puisys et al. (2022)	50	50	0	1	Straumann. BLT.	2	2	9
Raes et al. (2018)	11	11	0	1	AstraTech Osseospeed	1	4	6
da Rosa et al. (2014)	18	18	0	1	Nobel Replace tapred	2	3	7
Ross et al. (2014)	47	47	0	1	Nobel Biocare	NM	3	NM
Saedi Germi et al. (2020)	18	18	0	1	NM	NM	NM	NM
Sicilia-Felechosa et al. (2020)	40	40	1	1	Zimmer Biomet. Nobel Biocare Speedy	1/2	3	1
Slagter et al. (2021)	18	18	0	1	Nobel Biocare Nobel Active	2	3	3
Spinato et al. (2012)	45	45	0	1	Screw-Vent, Zimmer	2	1	2
Stoupel et al. (2016)	39	39	0	1	3i Biomet	2	16	2
Sun et al. (2020)	30	30	0	1	Nobel Replace	2	3	6
Takeshita et al. (2015)	21	21	0	1	OsseoSpeed. Dentsply implants	1	4	6
Tian et al. (2019)	30	27	0	1	Nobel Active, Nobel Biocare (18). Camlog Screw Line (12)	2	3	3
Tortamano et al. (2010)	12	12	0	1	Straumann, Tapered effect	2	1	2
Tsuda et al. (2011)	10	10	0	1	OsseoSpeed. Astra Tech	1	4	6
Valentini et al. (2010)	94	43	2	1	Astra Tech ST implants	2	4	2
van Nimwegen et al. (2016)	51	51	2	1	3i Osseotite	1	16	2
van Nimwegen et al. (2018)	60	58	1	1	Nobel Biocare. Nobel Active.	2	3	3
Vidigal et al. (2017)	53	53	2	1	NM	NM	NM	NM
Yang et al. (2019)	50	50	0	1	Straumann. Nobel Active. Osstem. Apollo. Dentium	2	2/3	2/3
Yoshino et al. (2014)	20	20	0	1	Straumann. Bone Level.	1	2	9
Zuiderveld et al. (2018)	60	58	2	1	Nobel Active. Nobel Biocare.	2	3	3

Note: Implant material: 1-Titanium; 2-Zirconia. Implant type: 1. Parallel-walled; 2. Tapered-walled; 3. Hybrid conical. Implant surface: 1-SLA; 2-SLActive; 3-TiUnite; 4-TiOblast; 5-Dual acid-etched, calcium phosphate; 6-Alumina particles; 7-Titanium-plasma sprayed; 8-Zirconia-Titanium; 9-Friadent plus; 10-Ca2 ions SLA; 11-phosphonated molecules of B+; 12-ZLA; 13-Laser lock; 14-Integra-Ti; 15-HRS Surface; 16-Dual acid-etched fine-micron topography. Implant connection type: 1-External hex; 2-Internal hex; 3- Connical hex; 4-Morse Taper; 5-Loking-Taper; 6-Connical connection; 7-Tri-channel; 8-internatl connection pure; 9-Internal Octogon-Crossfit; 10-Internal Octogon-Synocta.

Abbreviation: NM, Not mentioned.

TABLE 2C Surgical characteristics of the included studies.

Author (year)	Total number of implants	Implants included for assessment	Bone augmentation procedure	Bone augmentation material	Soft tissue augmentation procedure	Soft tissue augmentation material	Flap or flapless implant surgery
Arora and Ivanovski (2018)	20	20	2	Xenograft Bovine, Bio-OSS	NM	NM	1
Arora et al. (2017)	30	30	1	xenograft (Bio-Oss)	No	NM	1
Barone et al. (2016)	37	35	1	Zenograft Porcine, MP3, Osteobiol-Tecnoss	NM	NM	1
Bonnet et al. (2018)	39	39	1	Xenograft Bovine, Bio-OSS	Free CGT	NM	1
Bruno et al. (2014)	36	17	1	Xenograft Bovine, Bio-OSS	NM	NM	1
Cabello et al. (2013)	14	14	0	NM	NM	NM	1
Cardaropoli et al. (2015)	26	26	1	Xenograft Bovine, Bio-OSS	NM	NM	1
Cardaropoli et al. (2019)	20	20	1	; Botiss Biomaterials	NM	NM	1
Chan et al. (2019)	20	18	1	Human allograft, Puros	NM	NM	1
Cooper et al. (2014)	55	52	0	0	NM	NM	1
Cosyn et al. (2011)	32	25	1	Human allograft, Puros	NM	NM	2
Cosyn et al. (2013)	28	26	1	Xenograft Bovine, Bio-OSS	NM	NM	2
Cosyn et al. (2016)	22	17	1	Xenograft Bovine, Bio-OSS	NM	NM	2
Crespi et al. (2018)	30	30	0	0	NM	NM	1
Cristalli et al. (2015)	23	23	1	Xenograft Bovine, Bio-OSS	CGT	CGT	2
D'Avenia et al. (2019)	20	20	1/2	Xenograft Bovine, Bio-OSS	NM	NM	1
Degidi et al. (2014)	53	53	NM	NM	NM	NM	1
Esposito et al. (2015)	54	54	1	Xenograft Bovine, Bio-OSS	NM	NM	2
Felice et al. (2015)	50	50	1	Xenograft Bovine, Bio-OSS	NM	NM	2
Fürhauser et al. (2016)	77	77	1	Algae derived bone, Algipore Frios	NM	NM	1
Ganeles et al. (2017)	15	11	NM	NM	NM	NM	1/2
Guarnieri et al. (2016)	12	12	NM	NM	NM	NM	1
Groenendijk et al. (2020)	98	98	1	Autogenous bone graft	4 of 98	CGT	1
Hartlev et al. (2014)	68	54	NM	NM	NM	NM	NM
Hassani et al. (2021)	20	20	1	Biphasic calcium phosphate (Osteon II, Genoss)	NM	NM	1
Kan et al. (2011)	35	35	0	0	0	0	1
Khzam et al. (2014)	15	15	1	Xenograft Bovine, Bio-Oss, Geistlich	NM	NM	1
Kniha et al. (2017)	16	16	1	NM	NM	NM	1
Kolerman et al. (2016)	34	34	1	Xenograft Bovine, Bio-OSS Collagen	NM	NM	2
Kolerman et al. (2017)	39	39	1	Allograft (FDBA)	NM	NM	1

TABLE 2C (Continued)

Author (year)	Total number of implants	Implants included for assessment	Bone augmentation procedure	Bone augmentation material	Soft tissue augmentation procedure	Soft tissue augmentation material	Flap or flapless implant surgery
Lombardo et al. (2016)	21	21	1	Autogenous bone and beta-tricalcium phosphate	NM	NM	1
Ma et al. (2019)	28	17	NM	NM	NM	NM	1
Malchiodi et al. (2013)	64	64	1	Autogenous	NM	NM	1
Mangano et al. (2012)	21	21	1	Biphasic calcium phosphate granules (MBCPR; Biomatlante, Vigneux de Bretagne, France)	NM	NM	2
Mangano et al. (2013)	26	26	NM	NM	NM	NM	2
Mangano et al. (2017)	40	22	2	Calcium phosphate granules (Biocer)	9 of 42	CTG	2
Migliorati et al. (2015)	48	47	1	Xenograft Bovine, Bio-Oss, Geistlich	24 (yes) 24 (no)	CTG Palate	1
Noelken et al. (2011)	18	18	1	Autogenous	NM	NM	1
Noelken et al. (2018) (2)	26	26	1	Autogenous	13 (yes) 13 (no)	CTG palate	1
Östman et al. (2020)	19	19	1	Xenograft, mp3, Osteobiol, Tecnoss. Allograft, Zimmer Biomet	NM	NM	1
Paul and Held (2012)	33	31	1	Xenograft Bovine, Bio-Oss, Geistlich	Yes	CTG	1
Pieri et al. (2011)	38	37	1	Autogenous + xenograft, Bio-Oss	NM	NM	1
Puisys et al. (2022)	50	50	1	(A) allogenic; (B) allogenic + autogenous + collagen membrane	Yes	CTG tuberosity	1
Raes et al. (2018)	11	11	NM	NM	NM	NM	1
da Rosa et al. (2014)	18	18	1	Autogenous bone graft	NM	NM	1
Ross et al. (2014)	47	47	1	Cortical Allograft. Puros, Zimmer.	NM	NM	1
Saedi Germi et al. (2020)	18	18	1	Allograft	NM	NM	1
Sicilia-Felechosa et al. (2020)	40	40	1	Autogenous + xenograft, DBBM, Bio-Oss	Yes	Allogenic dermis	1
Slagter et al. (2021)	18	18	1	Autogenous + xenograft (Bio-Oss)	NM	NM	1
Spinato et al. (2012)	45	45	23 (0) 22 (1)	Autogenous, Xenograft bovine, Alograft, Combination	No	No	NM
Stoupel et al. (2016)	39	39	0	0	0	0	
Sun et al. (2020)	30	30	1	Xenograft Bovine, Bio-Oss, Geistlich	No	No	1
Takeshita et al. (2015)	21	21	1	Beta tricalcium phospate	No	No	1
Tian et al. (2019)	30	27	1	Xenograft (Bio-Oss)	No	No	1

(Continues)

TABLE 2C (Continued)

Author (year)	Total number of implants	Implants included for assessment	Bone augmentation procedure	Bone augmentation material	Soft tissue augmentation procedure	Soft tissue augmentation material	Flap or flapless implant surgery
Tortamano et al. (2010)	12	12	No	No	No	No	1
Tsuda et al. (2011)	10	10	1	Xenograft (Bio-Oss)	CTG	CTG	1
Valentini et al. (2010)	94	43	2	Xenograft (Bio-Oss)	NM	NM	2
van Nimwegen et al. (2016)	51	51	1	Autogenous + xenograft (endobon)	NM	NM	1
van Nimwegen et al. (2018)	60	58	1	Autogenous + xenograft bovine, Bio-Oss, Geistlich	30 (yes) 30 (no)	CTG tuberosity	1
Vidigal et al. (2017)	53	53	1	Xenograft (Bio-Oss)	16 of 53	CTG	1
Yang et al. (2019)	50	50	1	Xenograft, bovine, Bio-Oss. Artificial: Beta-TCP	No	No	1
Yoshino et al. (2014)	20	20	1	Autogenous + xenograft bovine, Bio-Oss, Geistlich	10 (yes) 10 (no)	CTG tuberosity	1
Zuiderveld et al. (2018)	30	58	1	Autogenous + xenograft, DBBM, Bio-Oss	30 (yes) 30 (no)	CTG tuberosity	1

Note: Bone augmentation procedure: 0-No bone augmentation; 1-Bone to implant gap, 2-GBR. Flap or Flapless implant surgery: 1-Flapless; 2. Flap.

midfacial recession, pink esthetic score (PES), and white esthetic score (WES). The follow-up times for the analysis were defined as 0 (baseline), 1–6, 12, 18–24, 33–44, and 48–96 months.

A summary of the meta-analysis focusing on esthetic outcomes providing the included study and implant counts and the measured heterogeneity of the individual studies is presented in Table 10. Table S7a–f presents the individual data of each index with respect to follow-up time, including the individual weight of each study. Available data were extracted for comparison between timepoints baseline and 12 months. Here, Table 11a summarizes the papilla height outcome, observed to be an overall effect size of −0.71 (−1.25, −0.17) mm after 1 year with respect to all included studies (Table 11a, Figure 2). For midfacial recession, an overall effect size (baseline to 12 months) of −0.15 (−0.66, 0.36) mm was estimated with Hedges' *g* effect size (Table 11b, Figure 3). PES index in the retrieved data reported an overall effect size of 0.82 (0.37–1.28) comparing baseline data to 12-month follow-up (Table 11c, Figure 4).

3.7 | Esthetic outcome – influence of individual groups – meta-analysis

During data extraction, groups were used to document the influence of individual treatment procedure characteristics. These data were compared within the individual index. Study inclusion depended on the individual information available in each study. The following characteristics could be included in the analysis: flap or flapless; type of implant (parallel or tapered walled), soft tissue procedure (yes or no), and implant connection (internal or conical hex). Use (or not) of a flap had no significant influence on the outcome of the papilla height, PES, or WES indices (Table 12). The type of implant used was differentiated into "parallel walled" and "tapered walled". The WES index was significantly influenced by the type of implant ($p = .049$), with the parallel-walled design outperforming the tapered one (Table 12). However, papilla height, midfacial recession, and PES were not influenced by the type of implant. Soft tissue procedures reported in the studies did not influence the outcome of the midfacial recession or the PES score (Table 12). The implant connection did not have an impact on the esthetic outcome or the PES/ WES (Table 12).

3.8 | Supplementary analysis – data extraction only focusing on RCTs

Additional data analysis was performed to describe the outcomes separating the RCTs from the other studies and comparing to prospective and retrospective investigations. Here, the failure rate of implants was higher reported in the RCTs (2.36 per 100 years) compared to less than 1 in observational studies. Similar results were obtained with the survival of restoration the RCTs had higher failure rate (4.07 per 100 years) compared with 0.71 for prospective and 0.51 retrospective studies. Overall, a similar trend was observed with surgical, technical, and biological complications. Here, especially the

TABLE 2D Restorative characteristics of the included studies.

Author (year)	Total number of implants	Implants included for assessment	Implant survival (number)	Type of occlusion in provisional	Provisional restoration retention system	Abutment provisional material	Definitive restoration retention system	Definitive abutment material	Restoration material	Restoration survival
Arora and Ivanovski (2018)	20	20	20	1	1	NM	1	4/5	4	20
Arora et al. (2017)	30	30	30	1	1	3	NM	NM	NM	30
Barone et al. (2016)	37	35	35	1	2	3	2	1	1	35
Bonnet et al. (2018)	39	39	39	1	1	3	2	1	1/5	39
Bruno et al. (2014)	36	17	17	3	1	3	NM	NM	NM	NM
Cabello et al. (2013)	14	14	14	1	1/2	NM	1	1/4	1/5	14
Cardaropoli et al. (2015)	26	26	26	1	1	2	2	NM	NM	26
Cardaropoli et al. (2019)	20	20	20	1	1	2	1	NM	4	20
Chan et al. (2019)	20	18	18	1	1	3	2	5	4	18
Cooper et al. (2014)	55	52	52	1	2	3	2	5	4	NM
Cosyn et al. (2011)	32	25	30	1	1	3	2	5	1	25
Cosyn et al. (2013)	28	26	28	1	1	3	2	5	NM	28
Cosyn et al. (2016)	22	17	17	1	1	2	1	NM	1/4	17
Crespi et al. (2018)	30	30	30	2	2	4	2	1	5	30
Cristalli et al. (2015)	23	23	23	2	1	3	2	5	1	23
D'Avenia et al. (2019)	20	20	20	NM	1	NM	NM	NM	5	20
Degidi et al. (2014)	53	53	53	1	2	3	2	5	1	53
Esposito et al. (2015)	54	54	52	1	NM	NM	2	NM	1	50
Felice et al. (2015)	50	50	23	1	2	NM	2	5	1	23
Fürhauser et al. (2016)	77	77	77	1	1	5	2	7	8	77
Ganeles et al. (2017)	15	11	15	1	NM	NM	NM	4/5	NR	15
Guarnieri et al. (2016)	12	12	12	1	2	3	2	5	NM	12
Groenendijk et al. (2020)	98	98	98	1	NM	3	NM	5	NM	98
Hartlev et al. (2014)	68	54	54	1	2	6	2	4/5	4/5	54
Hassani et al. (2021)	20	20	20	1	1	3	1/2	5	4/5	NM
Kan et al. (2011)	35	35	35	1	2	3	2	3	1	35
Khzam et al. (2014)	15	15	15	1	1	NM	NM	4	4	NM
Kniha et al. (2017)	16	16	16	1	2	NM	2	4	4	16
Kolerman et al. (2016)	34	34	34	0	NM	3	2	5	34	34
Kolerman et al. (2017)	39	39	39	1	2	NM	2	4	5	39
Lombardo et al. (2016)	21	21	20	NM	2	4	2	1	4	
Ma et al. (2019)	28	17	17	1	1	3	1	6	4	17
Malchiodi et al. (2013)	64	64	64	1	2	3	2	5	1/5	NM
Mangano et al. (2012)	21	21	26	2	2	3	2	1	1	26

(Continues)

TABLE 2D (Continued)

Author (year)	Total number of implants	Implants included for assessment	Implant survival (number)	Type of occlusion in provisional	Provisional restoration retention system	Abutment provisional material	Definitive restoration retention system	Definitive abutment material	Restoration material	Restoration survival
Mangano et al. (2013)	26	26	22	2	2	3	2	1	1	22
Mangano et al. (2017)	40	22	42	1	2	2	2	NM	1	42
Migliorati et al. (2015)	48	47	47	1	1	NM	NM	NM	NM	NM
Noelken et al. (2011)	18	18	18	1	2	3	2	NM	1.5	NM
Noelken et al. (2018) (2)	26	26	26	1	1/2	3	2	5	5	NM
Östman et al. (2020)	19	19	19	1	1	2/3	1	NM	4	NM
Paul and Held (2012)	33	31	31	1	1	3	2	5	4	NM
Pieri et al. (2011)	38	37	37	1	1	3	2	4/5	1/4	37
Puisys et al. (2022)	50	50	25	1	1	3	1	5	5	NM
Raes et al. (2018)	11	11	11	1	2	3	2	5	4	11
da Rosa et al. (2014)	18	18	18	NM	1	3	2	4	4	18
Ross et al. (2014)	47	47	47	1	2	3	2	4/5	1/4	NM
Saedi Germi et al. (2020)	18	18	18	NM	NM	NM	NM	NM	NM	NM
Sicilia-Felechosa et al. (2020)	40	40	39	1	1	3	NM	NM	NM	NM
Slagter et al. (2021)	18	18	18	NM	1	NM	1/2	4	4	18
Spinato et al. (2012)	45	45		1	1		NM	NM	NM	45
Stoupel et al. (2016)	39	39	38	1	1	3	NM	NM	NM	NM
Sun et al. (2020)	30	30	30	1	2	NM	2	NM	5	NM
Takeshita et al. (2015)	21	21	21	1	2	3	2	1/4/5	1/4	NM
Tian et al. (2019)	30	27	27	1	1	NM	NM	NM	NM	NM
Tortamano et al. (2010)	12	12	12	1	1	3	1	NM	1	12
Tsuda et al. (2011)	10	10	10	1	2	3	2	4	4	NM
Valentini et al. (2010)	94	43	41	1	2	NM	2	NM	NM	41
van Nimwegen et al. (2016)	51	51	49	1	1	2	2	5	4	49
van Nimwegen et al. (2018)	60	58	58	1	1	NM	1/2	4	5	NM
Vidigal et al. (2017)	53	53	51	1	2	3	NM	NM	NM	51
Yang et al. (2019)	50	50	50	1	1	NM	NM	NM	NM	NM
Yoshino et al. (2014)	20	20	20	1	1	3	2	4	4	NM
Zuiderveld et al. (2018)	30	58	58	1	1	3	1/2	4	4	NM

Note: Type of occlusion in provisional: 1-Nonfunctional occlusion; 2-Full contact in centric occlusion; 3-Maximum intercuspation. Provisional restoration retention system: 1-Screw retained; 2-Cement retained. Abutment provisional material: 1-Plastic; 2-PEEK; 3-Titanium; 4-Metal; 5-Titanium-Zirconia; 6-Zirconia. Definitive restoration retention system: 1-Screw retained; 2-Cement retained. Definitive abutment material: 1-Metal; 2-Co-Cr; 3-Gold; 4-Zirconia; 5-Titanium; 6-Gold-Zirconia; 7-Titanium-Zirconia. Restoration material: 1-Metal-Ceramic; 2-Titanium; 3-Gold; 4-Ceramic; 5-Zirconia; 6-Cr-Co; 7-Metal; 8-leucite glass- ceramic; 9-Lithium disilicate; 10-zirconia-veneering porcelain; 11-zirconia-based.

Abbreviation: NM, Not mentioned.

TABLE 2E Complications and marginal/crestal bone loss of the included studies.

Author (year)	Total number of implants	Implant and surgical complications		Biological complications		Technical complications		Marginal/crestal bone loss	
		Type	Number of implants	Type	Number of implants	Type	Number of implants	Mesial	Distal
Arora and Ivanovski (2018)	20	5	2	6	1	0	0	0.05 ± 0.65	0.06 ± 0.52
Arora et al. (2017)	30	NM	NM	7	1	0	0	0.18 ± 1.38	0.34 ± 1.40
Barone et al. (2016)	37	11	2	0	0	NM	NM	1.00 ± 0.00	
Bonnet et al. (2018)	39	NM	NM	8	2	0	0	NM	NM
Bruno et al. (2014)	36	6	3	NM	NM	NM	NM	NM	NM
		7	2						
Cabello et al. (2013)	14	NM	NM	0	0	1	3	NM	NM
						5	1		
						6	1		
Cardaropoli et al. (2015)	26	0	0	NM	NM	NM	NM	NM	NM
Cardaropoli et al. (2019)	20	0	0	0	0	0	0	NM	NM
Chan et al. (2019)	20	14	2	NM	NM	NM	NM	0.7 ± 0.6	
Cooper et al. (2014)	55	11	3	NM	NM	NM	NM	0.43 ± 1.00	
Cosyn et al. (2011)	32	0	0	0	0	5	1	1.13 ± 0.43	0.86 ± 0.54
Cosyn et al. (2013)	28	NM	5	NM	NM	NM	NM	NM	NM
Cosyn et al. (2016)	22	8	2	3	1	4	1	0.19 ± 0.30	
						5	1		
						7	1		
Crespi et al. (2018)	30	0	0	NM	NM	NM	NM	NM	NM
Cristalli et al. (2015)	23	0	0	0	0	0	0	0.383 ± 0.512	0.278 ± 0.595
D'Avenia et al. (2019)	20	NM	NM	NM	NM	NM	NM	0.59 ± 1.04	0.63 ± 1.18
Degidi et al. (2014)	53	0	0	4	3	NM	NM	NM	NM
Esposito et al. (2015)	54	7	19	4	1	7	4	0.23 ± 0.11	
				5	1				
Felice et al. (2015)	50	NM	NM	NM	NM	8	2	0.15 ± 0.10	
Fürhauser et al. (2016)	77	NM	NM	NM	NM	NM	NM	NM	NM
Ganeles et al. (2017)	15	NM	NM	0	0	0	0	−1.40 ± 1.89	
Guarnieri et al. (2016)	12	NM	NM	NM	NM	NM	NM	0.35 ± 0.18	
Groenendijk et al. (2020)	98	10	1	2	1	1	1	NM	NM

(Continues)

TABLE 2E (Continued)

Author (year)	Total number of implants	Implant and surgical complications		Biological complications		Technical complications		Marginal/crestal bone loss	
		Type	Number of implants	Type	Number of implants	Type	Number of implants	Mesial	Distal
Hartlev et al. (2014)	68	NM	NM	NM	NM	NM	NM	NM	NM
Hassani et al. (2021)	20	0	0	0	0	0	0	1.53 ± 0.10	
Kan et al. (2011)	35	NM	NM	0	0	0	0	0.72 ± 0.27	−0.63 ± 0.21
Khzam et al. (2014)	15	NM	NM	NM	NM	NM	NM	1.20 ± 1.01	0.80 ± 1.14
Kniha et al. (2017)	16	0	0	0	0	0	0	NM	NM
Kolerman et al. (2016)	34	NM	2	0	0	0	0	3.82 ± 0.87	
Kolerman et al. (2017)	39	NM	NM	NM	NM	NM	NM	1.90 ± 0.54	1.50 ± 0.51
Lombardo et al. (2016)	21	3	1	0	0	5	3	NM	NM
Ma et al. (2019)	28	5 6 7	3 4 2	NM	NM	0	0	−0.1 ± −0.25	
Malchiodi et al. (2013)	64	0	0	0	0	0	0	0.70 ± 0.50	0.90 ± 0.70
Mangano et al. (2012)	21	0	0	0	0	0	0	0.44 ± 0.14	
Mangano et al. (2013)	26	0	0	0	0	0	0	0.45 ± 0.15	
Mangano et al. (2017)	40	NM	NM	5	3	1 4 6	2 2 5	NM	NM
Migliorati et al. (2015)	48	0	0	NM	NM	NM	NM	−0.115 ± 0.162 −0.165 ± 0.055	−0.005 ± 0.021 −0.167 ± 0.072
Noelken et al. (2011)	18	NM	NM	1	1	NM	NM	1.30	1.00
Noelken et al. (2018) (2)	26	0	0	NM	NM	NM	NM	0.00 ± 0.70 0.10 ± 0.30	
Östman et al. (2020)	19	NM	NM	NM	NM	NM	NM	NM	NM
Paul and Held (2012)	33	NM	NM	0	0	NM	NM	NM	NM
Pieri et al. (2011)	38	5	1	NM	NM	NM	NM	0.2 ± 0.17 0.51 ± 0.24	
Puisys et al. (2022)	50	0	0	0	0	0	0	0.1 ± 0.21	0.2 ± 0.25
Raes et al. (2018)	11	NM	NM	NM	NM	NM	NM	NM	NM
da Rosa et al. (2014)	18	NM	NM	NM	NM	NM	NM	NM	NM

TABLE 2E (Continued)

Author (year)	Total number of implants	Implant and surgical complications		Biological complications		Technical complications		Marginal/crestal bone loss	
		Type	Number of implants	Type	Number of implants	Type	Number of implants	Mesial	Distal
Ross et al. (2014)	47	NM	NM	NM	NM	NM	NM	NM	NM
Saedi Germi et al. (2020)	18	NM	NM	NM	NM	NM	NM	NM	NM
Sicilia-Felechosa et al. (2020)	40	10	1	NM	NM	NM	NM	0.2 ± 0.16	
Slagter et al. (2021)	18	NM	NM	NM	NM	NM	NM	0.71 ± 0.68	0.71 ± 0.71
Spinato et al. (2012)	45	NM	NM	NM	NM	NM	NM	0.94 ± 0.51	
								0.90 ± 0.49	
Stoupel et al. (2016)	39	14	1	6	7	NM	NM	0.47 ± 0.98	0.59 ± 1.05
				1	2			0.73 ± 1.18	1.33 ± 1.23
Sun et al. (2020)	30	0	0	NM	NM	NM	NM	NM	NM
Takeshita et al. (2015)	21	NM	NM	NM	NM	NM	NM	0.56 ± 1.28	
Tian et al. (2019)	30	NM	NM	NM	NM	6	1	NM	NM
Tortamano et al. (2010)	12	NM	NM	NM	NM	NM	NM	NM	NM
Tsuda et al. (2011)	10	3	3	1	1	NM	NM	−0.14 ± 0.33	−0.14 ± 0.30
Valentini et al. (2010)	94	NM	NM	5	2	NM	NM	0.18 ± 0.66	0.43 ± 0.95
van Nimwegen et al. (2016)	51	14	2	NM	NM	NM	NM	NM	NM
van Nimwegen et al. (2018)	60	10	1	NM	NM	NM	NM	NM	NM
Vidigal et al. (2017)	53	14	2	NM	NM	1	1	NM	NM
						2	1		
						5	7		
Yang et al. (2019)	50	NM	NM	NM	NM	NM	NM	1.21 ± 1.44	
Yoshino et al. (2014)	20	3	1	1	1	5	1	−0.07 ± 0.16	
				2	1	7	1	−0.31 ± 0.41	
Zuiderveld et al. (2018)	30	NM	NM	NM	NM	NM	NM	0.04 ± 0.46	0.02 ± 0.37
								0.06 ± 0.42	0.03 ± 0.38

Note: Implant and surgical complications. 3: lack of stability; 5: draining sinus/bone dehiscence; 6: bone fenestration; 7: lack of stability; 8: midfacial recession; 10: soft tissue complication; 11: implant loss; 14: osteointegration failure. Biological complications: 1: periimplantitis; 2: fistula; 3: esthetic complications; 4: discomfort; 5: pain; 6: mucosal inflammation; 7: draining sinus; 8: acute infection. Technical complications: 1: screw loosening; 2: screw fracture; 4: chipping; 5: decementation; 6: crown loosening; 7: provisional crown broken; 8: loss of retention.

Abbreviation: NM: Not mentioned.

TABLE 2F Esthetic outcomes characteristics of the included studies.

Author (year)	Papilla height		Papilla index		Mid-facial/mid-buccal soft tissue recession	Pink esthetic score (Belser)	Pink esthetic score (Fürhauser)	White esthetic score
	Mesial	Distal	Mesial	Distal				
Arora and Ivanovski (2018)	NM	NM	NM	NM	NM	NM	11.1	8.4
Arora et al. (2017)	0.06 ± 0.66	0.06 ± 0.58	NM	NM	−0.23 ± 0.69	NM	11.25 ± 1.36	NM
Barone et al. (2016)	NM	NM	2.71 ± 0.45	2.71 ± 0.45	NM	7.71 ± 0.72	NM	NM
Bonnet et al. (2018)	NM	NM	NM	NM	NM	7.07 ± 1.328	NM	NM
Bruno et al. (2014)	NM	NM	2.00	1.82	NM	NM	NM	NM
Cabello et al. (2013)	−0.38 ± 0.68	−0.80 ± 0.96	NM	NM	−0.45 ± 0.25	NM	NM	NM
Cardaropoli et al. (2015)	−0.17 ± 0.28	−0.08 ± 0.18	NM	NM	−0.21 ± 0.32	NM	11.45 ± 1.45	NM
Cardaropoli et al. (2019)	−0.03 ± 0.34	−0.03 ± 0.34	NM	NM	0.08 ± 0.49	NM	12.55 ± 1.00	NM
Chan et al. (2019)	0.4 ± 1.00	0.5 ± 1.4	NM	NM	−0.10 ± 0.9	NM	NM	NM
Cooper et al. (2014)	−0.13 ± 1.61	−0.21 ± 1.61	NM	NM	0.06 ± 0.98	NM	NM	NM
Cosyn et al. (2011)	−0.05 ± 0.83	−0.08 ± 1.24	NM	NM	−0.34 ± 0.80	NM	10.48 ± 2.7	8.17 ± 1.52
Cosyn et al. (2013)	NM	NM	NM	NM	NM	NM	10.88 ± 2.41	NM
Cosyn et al. (2016)	0.09 ± 0.33	−0.25 ± 0.45	NM	NM	−0.53 ± 0.53	NM	11.18 ± 1.38	NM
Crespi et al. (2018)	NM	NM	NM	NM	−0.30	NM	10.88 ± 2.41	NM
Cristalli et al. (2015)	NM	NM	NM	NM	NM	7.96 ± 1.19	NM	9.00 ± 1.22
D'Avenia et al. (2019)	NM	NM	NM	NM	NM	NM	8.90 ± 1.20	NM
Degidi et al. (2014)	0.01 ± 0.18	−0.03 ± 0.13	NM	NM	−0.59 ± 0.21	NM	NM	NM
	0.08 ± 0.16	0.10 ± 0.17	NM	NM	−0.35 ± 0.12	NM		
Esposito et al. (2015)	NM	NM	NM	NM	NM	NM	13 ± 1.5	NM
Felice et al. (2015)	NM	NM	NM	NM	NM	NM	12.78 ± 0.42	NM
Fürhauser et al. (2016)	NM	NM	NM	NM	NM	NM	12.60	NM
Ganeles et al. (2017)	NM	NM	2.45	2.64	NM	NM	10	NM
Guarnieri et al. (2016)	0.41 ± 0.41	0.35 ± 0.83	NM	NM	−0.06 ± 0.61	NM	11.06 ± 0.63	7.32 ± 0.71
Groenendijk et al. (2020)	NM	NM	NM	NM	NM	NM	12 ± 2.0	NM
Hartlev et al. (2014)	NM	NM	NM	NM	NM	NM	9.9	7.70
Hassani et al. (2021)	NM	NM	NM	NM	NM	NM	11.2 ± 1.1	8.00 ± 1.02
Kan et al. (2011)	−0.22 ± 0.34	−0.21 ± 0.41	NM	NM	−1.13 ± 0.87	NM	NM	NM
Khzam et al. (2014)	−0.50 ± 1.12	−0.30 ± 0.82	NM	NM	−0.20 ± 0.78	NM	NM	NM
Kniha et al. (2017)	0.83 ± 0.65		NM	NM	NM	NM	NM	NM
Kolerman et al. (2016)	NM	NM	NM	NM	−0.54	7.12 ± 1.89	NM	7.32 ± 1.25
Kolerman et al. (2017)	NM	NM	NM	NM	−0.41	7.92 ± 1.6	NM	7.66 ± 1.48

TABLE 2F (Continued)

Author (year)	Papilla height		Papilla index		Mid-facial/mid-buccal soft tissue recession	Pink esthetic score (Belser)	Pink esthetic score (Fürhauser)	White esthetic score
	Mesial	Distal	Mesial	Distal				
Lombardo et al. (2016)	NM	NM	NM	NM	NM	7.86 ± 0.8	NM	9.50 ± 0.8
Ma et al. (2019)	NM	NM	2.29	2.12	0.28 ± 0.20	NM	NM	NM
Malchiodi et al. (2013)	0.60 ± 0.50	0.80 ± 0.60	NM	NM	0.50 ± 0.60	NM	NM	NM
Mangano et al. (2012)	NM	NM	NM	NM	NM	7.3 ± 1.17	NM	7.00 ± 1.35
Mangano et al. (2013)	NM	NM	NM	NM	NM	7.45 ± 1.63	NM	7.04 ± 1.29
Mangano et al. (2017)	NM	NM	NM	NM	NM	7.8 ± 1.8	NM	8.60 ± 1.7
Migliorati et al. (2015)	0.8	0.6	NM	NM	−0.41 ± 0.38 −0.22 ± 0.24	7.15 ± 1.75	NM	7.98 ± 0.99
	0.8	0.7			−0.93 ± 0.58 −0.35 ± 0.36			
Noelken et al. (2011)	NM	NM	NM	NM	NM	NM	12.5	NM
Noelken et al. (2018) (2)	NM	NM	NM	NM	−1.00 ± 0.70 −0.40 ± 0.70	NM	12.2 ± 0.6 13.0 ± 1.20	NM
Östman et al. (2020)	NM	NM	NM	NM	NM	NM	13.0	NM
Paul and Held (2012)	NM	NM	NM	NM	NM	8.39 ± 1.33	NM	9.50 ± 0.65
Pieri et al. (2011)	−0.24 ± 0.21 −0.33 ± 0.19	−0.28 ± 0.19 −0.33 ± 0.23	NM	NM	−0.61 ± 0.54 −0.73 ± 0.52	NM	NM	NM
Puisys et al. (2022)	NM	NM	NM	NM	0.0 ± 0.1	NM	12.8 ± 1.19	NM
Raes et al. (2018)	NM	NM	NM	NM	NM	NM	10.63 ± 2.11	NM
da Rosa et al. (2014)	0.20	0.30	NM	NM	0.6	NM	NM	NM
Ross et al. (2014)	NM	NM	NM	NM	−0.30	NM	NM	NM
Saedi Germi et al. (2020)	NM	NM	NM	NM	NM	8.58 ± 1.003	NM	NM
Sicilia-Felechosa et al. (2020)	NM	NM	NM	NM	NM	NM	12.43 ± 2.13	NM
Slagter et al. (2021)	NM	NM	2.56 ± 0.78	2.5 ± 0.79	NM	7.83 ± 1.69	NM	7.50 ± 2.12
Spinato et al. (2012)	NM	NM	NM	NM	−0.40 ± 0.60 −0.30 ± 0.36	NM	NM	NM
Stoupel et al. (2016)	−0.09 ± 0.27 −0.22 ± 0.43	−0.06 ± 0.25 −0.28 ± 0.39	NM	NM	−0.22 ± 0.31 −0.42 ± 0.52	NM	NM	NM

(Continues)

TABLE 2F (Continued)

Author (year)	Papilla height		Papilla index		Mid-facial/mid-buccal soft tissue recession	Pink esthetic score (Belser)	Pink esthetic score (Fürhauser)	White esthetic score
	Mesial	Distal	Mesial	Distal				
Sun et al. (2020)	−0.59 ± 0.13 −1.17 ± 0.19	−0.58 ± 0.13 −1.22 ± 0.33	NM	NM	−0.59 ± 0.09 −1.09 ± 0.22	NM	12.07 ± 1.62 11.33 ± 1.76	NM
Takeshita et al. (2015)	NM	NM	NM	NM	NM	NM	10.24 ± 2.39	8.29 ± 1.62
Tian et al. (2019)	NM	NM	NM	NM	−0.24 ± 0.37	NM	NM	NM
Tortamano et al. (2010)	−0.14	−0.03	NM	NM	−0.03	NM	NM	NM
Tsuda et al. (2011)	NM	NM	2.00	2.60	−2.25 ± 1.21	NM	NM	NM
Valentini et al. (2010)	NM	NM	2.81 ± 0.50	2.81 ± 0.50	NM	NM	NM	NM
van Nimwegen et al. (2016)	NM	NM	NM	NM	NM	7.35 ± 1.23	NM	9.14 ± 0.94
van Nimwegen et al. (2018)	NM	NM	NM	NM	0.20 ± 0.70 −0.48 ± 1.13	NM	11.28 ± 1.67 11.36 ± 1.65	NM
Vidigal et al. (2017)	NM	NM	NM	NM	NM	NM	8.63 ± 2.40	6.92 ± 1.67
Yang et al. (2019)	−0.21 ± 0.80	−0.36 ± 0.79	1.9 ± 0.74	2.16 ± 0.76	−0.05 ± 0.92	NM	NM	NM
Yoshino et al. (2014)	NM	NM	2.1 2.4	2.2 1.9	−0.25 ± 0.35 −0.70 ± 0.48	NM	NM	NM
Zuiderveld et al. (2018)	−0.3 ± 0.7 −0.4 ± 1.0	−0.4 ± 0.7 −0.6 ± 0.6	NM	NM	0.10 ± 0.80 −0.50 ± 1.1 −0.52 ± 1.16	6.4 ± 1.5 6.8 ± 1.5	NM	7.40 ± 1.3

Abbreviation: NM, Not mentioned.

TABLE 3A Quality assessment of cohort included studies using the Newcastle-Ottawa scale.

Study	Selection				Comparability		Outcome			Number of stars (out of 9)
	S1	S2	S3	S4	C1	C2	E1	E2	E3	
Arora et al. (2017)	★	0	★	★	0	0	★	★	★	6
Arora and Ivanovski (2018)	★	0	★	★	★	0	★	★	★	6
Barone et al. (2016)	★	0	★	★	0	0	★	★	★	6
Bonnet et al. (2018)	★	0	★	★	0	0	0	★	★	5
Bruno et al. (2014)	★	0	★	★	0	0	0	★	★	5
Cabello et al. (2013)	★	0	0	★	0	0	0	★	★	4
Cardaropoli et al. (2015)	★	0	★	★	0	0	0	★	★	5
Cardaropoli et al. (2019)	★	0	★	★	0	0	0	★	★	5
Cooper et al. (2014)	★	★	0	★	★	★	0	★	★	7
Cosyn et al. (2011)	★	0	★	★	0	0	★	★	★	7
Cosyn et al. (2013)	★	★	★	★	★	★	★	★	★	9
Cosyn et al. (2016)	★	0	★	★	0	0	0	★	★	5
Cristalli et al. (2015)	★	0	★	★	0	0	★	★	★	6
D'Avenia et al. (2019)	★	0	★	★	0	0	0	★	★	5
Fürhauser et al. (2016)	★	0	★	★	0	0	★	★	★	7
Ganeles et al. (2017)	★	0	★	★	0	0	★	★	★	6
Guarnieri et al. (2016)	★	★	★	★	★	★	★	★	★	9
Groenendijk et al. (2020)	★	0	★	★	0	0	0	★	★	5
Hartlev et al. (2014)	★	0	★	★	0	0	0	★	0	4
Hassani et al. (2021)	★	0	0	★	★	★	0	★	★	6
Kan et al. (2011)	★	0	★	★	★	★	0	★	★	7
Khzam et al. (2014)	★	0	★	★	0	0	0	★	★	5
Kniha et al. (2017)	★	0	★	★	★	★	0	★	★	7
Kolerman et al. (2016)	★	0	★	0	0	0	0	★	★	4
Kolerman et al. (2017)	★	0	★	★	0	0	0	★	★	5
Lombardo et al. (2016)	★	0	0	★	0	0	0	★	★	4
Ma et al. (2019)	★	0	★	★	0	0	★	★	★	6
Malchiodi et al. (2013)	★	0	0	★	0	0	0	★	★	4
Mangano et al. (2012)	★	0	★	★	0	0	0	★	★	5
Mangano et al. (2013)	★	0	★	★	★	0	0	★	★	6
Mangano et al. (2017)	★	0	★	★	0	0	0	★	★	5
Migliorati et al. (2015)	★	★	★	★	★	★	★	★	★	9
Noelken et al. (2011)	★	0	★	★	0	0	0	★	★	5
Noelken et al. (2018)	★	★	★	★	★	★	0	★	★	8
Östman et al. (2020)	★	0	★	★	0	0	0	★	★	5
Paul and Held (2012)	★	0	★	★	0	0	0	★	★	5
Ross et al. (2014)	★	0	0	★	0	0	0	★	★	4
Raes et al. (2018)	★	★	★	★	★	★	0	★	★	8
da Rosa et al. (2014)	★	0	★	★	0	0	0	★	★	5
Saedi Germi et al. (2020)	★	0	0	★	0	0	0	★	★	4
Sicilia-Felechosa et al. (2020)	★	0	★	★	0	0	0	★	★	6
Slagter et al. (2021)	★	★	★	★	★	★	0	★	★	8
Spinato et al. (2012)	★	0	0	★	★	★	0	★	★	6
Sun et al. (2020)	★	★	★	★	★	★	0	★	★	8
Takeshita et al. (2015)	★	0	0	★	0	0	0	★	★	4
Tian et al. (2019)	★	0	★	★	0	0	0	★	★	5
Tortamano et al. (2010)	★	0	★	★	0	0	0	★	★	5
Tsuda et al. (2011)	★	0	★	★	0	0	0	★	★	5
Valentini et al. (2010)	★	0	0	★	0	0	0	★	0	3
van Nimwegen et al. (2016)	★	0	★	★	0	0	0	★	★	5
Vidigal et al. (2017)	★	0	★	★	0	0	0	★	★	3
Yang et al. (2019)	★	0	★	★	0	0	0	★	★	5
Yoshino et al. (2014)	★	★	★	★	★	★	0	★	★	8

TABLE 3B Quality assessment of randomized clinical trials, according to RoB 2 bias tool (risk of bias).

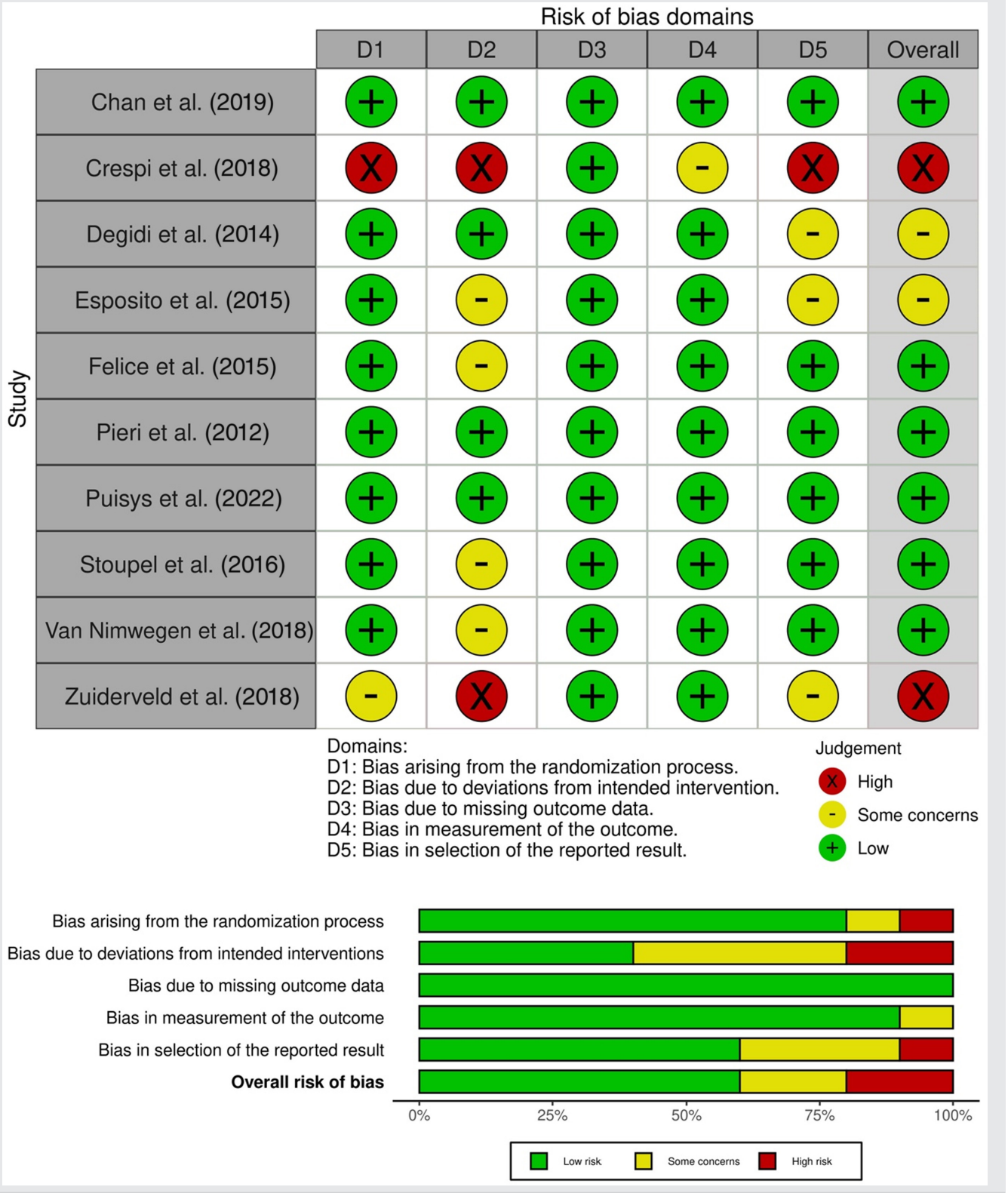

TABLE 4 Survival of implants (failures [X] of immediate implants [U]) – failure rates of studies.

Study ID	Author (year)	Patients included	Mean exposure time (months)	Immediate implants	Failures	Failure rate per year (95% CI)[a]
1	Arora et al. (2017)	30	47	30	0	0 (0–3.1[b])
2	Arora and Ivanovski (2018)	20	37	40	0	0 (0–3.0[b])
3	Barone et al. (2016)	30	84	37	2	0.8 (0.1–2.8)
4	Bonnet et al. (2018)	39	12	39	0	0 (0–9.5[b])
5	Bruno et al. (2014)	12	12	36	0	0 (0–10.2[b])
6	Cabello et al. (2013)	14	12	14	0	0 (0–26.3[b])
7	Cardaropoli et al. (2015)	26	12	26	0	0 (0–14.2[b])
8	Cardaropoli et al. (2019)	20	12	20	0	0 (0–18.4[b])
9	Chan et al. (2019)	18	12	20	2	10.0 (1.2–36.1)
10	Cooper et al. (2014)	45	60	55	3	1.1 (0.2–3.2)
11	Cosyn et al. (2011)	25	36	32	1	1.0 (0.0–5.8)
12	Cosyn et al. (2013)	28	33	28	3	3.9 (0.8–11.4)
14	Crespi et al. (2018)	60	48	30	0	0 (0–3.1[b])
15	Cristalli et al. (2015)	24	12	25	2	8.0 (1.0–28.9)
17	Degidi et al. (2014)	53	24	53	0	0 (0–3.5[b])
18	Esposito et al. (2015)	54	12	54	2	3.7 (0.4–13.4)
19	Felice et al. (2015)	25	12	25	2	8.0 (1.0–28.9)
20	Fürhauser et al. (2016)	77	60	77	0	0 (0–1.0[b])
21	Ganeles et al. (2017)	11	24	15	0	0 (0–12.3[b])
22	Guarnieri et al. (2016)	25	36	12	0	0 (0–10.2[b])
23	Groenendijk et al. (2020)	98	12	98	0	0 (0–3.8[b])
24	Hartlev et al. (2014)	54	33	54	1	0.7 (0.0–3.8)
25	Hassani et al. (2021)	20	12	20	0	0 (0–18.4[b])
26	Kan et al. (2011)	35	48	35	0	0 (0–2.6[b])
27	Khzam et al. (2014)	13	23.2	15	0	0 (0–12.7[b])
28	Kniha et al. (2017)	16	12	16	0	0 (0–23.1[b])
30	Kolerman et al. (2017)	39	44.82	39	1	0.7 (0.0–3.8)
31	Lombardo et al. (2016)	16	23.3	21	1	2.5 (0.1–13.7)
32	Ma et al. (2019)	16	60	28	2	1.4 (0.2–5.2)
33	Malchiodi et al. (2013)	58	36	64	0	0 (0–1.9[b])
34	Mangano et al. (2012)	26	24	26	1	1.9 (0.0–10.7)
35	Mangano et al. (2013)	40	31.09	22	0	0 (0–6.5[b])
36	Mangano et al. (2017)	103	36	42	0	0 (0–2.9[b])
37	Migliorati et al. (2015)	48	24	48	0	0 (0–3.8[b])
38	Noelken et al. (2011)	16	22	18	0	0 (0–11.2[b])
39	Noelken et al. (2018), ABG	14	61	13	0	0 (0–5.6[b])
39	Noelken et al. (2018), ABG + CTG	13	29	13	0	0 (0–11.7[b])
40	Östman et al. (2020)	19	19	19	0	0 (0–12.3[b])
41	Paul and Held (2012)	26	40.8	31	0	0 (0–3.5[b])
42	Pieri et al. (2011), T: Platform switch abutment	19	12	19	1	5.3 (0.1–29.3)
42	Pieri et al. (2011), C: Conventional abutment	19	12	19	0	0 (0–19.4[b])
43	Puisys et al. (2022)	25	12	25	0	0 (0–14.8[b])
44	Raes et al. (2018)	29	96	11	0	0 (0–4.2[b])
45	da Rosa et al. (2014)	18	58.56	18	0	0 (0–4.2[b])
46	Ross et al. (2014)	47	60	47	0	0 (0–1.6[b])

(Continues)

TABLE 4 (Continued)

Study ID	Author (year)	Patients included	Mean exposure time (months)	Immediate implants	Failures	Failure rate per year (95% CI)[a]
47	Saedi Germi et al. (2020)	18	12	18	0	0 (0–20.5[b])
48	Sicilia-Felechosa et al. (2020)	40	41.28	40	1	0.7 (0.0–4.0)
49	Slagter et al. (2021)	40	60	18	0	0 (0–4.1[b])
50	Spinato et al. (2012)	41	32	45	0	0 (0–3.1[b])
51	Stoupel et al. (2016), Flap	21	12	21	1	4.8 (0.1–26.5)
53	Takeshita et al. (2015)	18	18	21	0	0 (0–11.7[b])
54	Tian et al. (2019)	27	12	30	0	0 (0–12.3[b])
55	Tortamano et al. (2010)	12	18	12	0	0 (0–20.5[b])
56	Tsuda et al. (2011)	10	12	10	0	0 (0–36.9[b])
57	Valentini et al. (2010)	40	12	43	2	4.7 (0.6–16.8)
58	van Nimwegen et al. (2016)	51	48	51	2	1.0 (0.1–3.5)
59	van Nimwegen et al. (2018)	60	12	60	1	1.7 (0.0–9.3)
60	Vidigal et al. (2017)	53	51	53	2	0.9 (0.1–3.2)
61	Yang et al. (2019)	40	12	50	0	0 (0–7.4[b])
63	Zuiderveld et al. (2018), T: with CTG	29	12	30	1	3.3 (0.1–18.6)
63	Zuiderveld et al. (2018), C: without CTG	29	12	30	1	3.3 (0.1–18.6)

[a]Assuming poisson distributed failures.

[b]One-sided confidence interval.

biological complications present different findings when RCT studies are analyzed separately with a value of 6.22 in RCTs compared to 0.60 in prospective and 1.70 in retrospective studies.

4 | DISCUSSION

Treatment approaches in the field of oral implantology should be evaluated by combining the surgical and prosthetic phases and evaluating the overall outcome of the combined pathway. The goal of achieving a successful, long-lasting, and esthetic outcome is dependent on both the surgical and prosthetic phase and should therefore be evaluated from an objective view with respect to their combined treatment. Gallucci et al. (2018) emphasized the importance of assessing outcomes considering the implant-prosthetic concept as a single variable (Gallucci et al., 2018; Papaspyridakos et al., 2012). Immediate placement is defined as Type 1 treatment, placing the implant on the day of dental extraction (Chen et al., 2004; Chen & Buser, 2009; Hämmerle et al., 2004).

Within the evolution of results published by the ITI (International Team of Implantology) Consensus Conferences, the definition of immediate loading has been modified over the years. The latest version is that the restoration (provisional or final) is loaded in the first week following implant placement (Gallucci et al., 2014; Weber et al., 2009). In the last ITI Consensus Conference, a novel classification of combining immediate implant placement and immediate loading was proposed and defined as Type 1A (Gallucci et al., 2018).

With the data from the 63 studies published since 2010 and included here (10 randomized controlled trials, 28 prospective cohort and 25 retrospective cohort studies), a meta-analysis could be performed to evaluate the esthetic outcome and clinical performance of implants and their supported restorations inserted with Type 1A implant placement and loading in the maxillary anterior zone.

The overall survival rate of the implants calculated up to 5 years (95.8 (93.3–97.4) %) are similar to other implant placement concepts, and the survival of the restorations was also acceptable after 5 years (94.8%). 10-year data on the outcome of fixed implant-supported restorations presented survival rates of 95.5% in the literature (Wittneben, Buser, et al., 2014; Wittneben, Millen, et al., 2014) with a 98.8% implant survival rate (Buser et al., 2012). No influence of the retention type (screw vs. cement) on survival rate was observed. This has been confirmed in a specific meta-analysis focusing on this topic (Wittneben et al., 2017; Wittneben, Buser, et al., 2014; Wittneben, Millen, et al., 2014). Complications during the surgical phase were more frequent than the incidence of biological and technical complications of the restorations.

Multiple tools have been introduced to evaluate esthetic outcomes in implant treatment. Two of the most commonly used and accepted subjective tools currently available are the pink (PES) and white (WES) esthetic scores. PES was initially proposed by Fürhauser et al. (2005) to evaluate the peri-implant mucosa using seven distinct peri-implant soft tissue parameters. These parameters are the presence and absence of mesial and distal papillae, level of the facial mucosal margin, soft tissue contour, alveolar process deficiency (facial convexity), soft tissue color, and soft tissue texture. Each parameter has a score ranging from 0 to 2 with two being the best score and zero the poorest score, for a total possible score of 14. Belser et al. (2009) proposed a modification to

TABLE 5 Survival of restorations – (failure/survival [BB] of immediate loading [AO]) – failure rate per study.

Study ID	Author (year)	Patients included	Mean exposure time (months)	Immediate loadings	Failures	Failure rate per year (95% CI)[a]
1	Arora et al. (2017)	30	47	30	0	0 (0–3.1[b])
2	Arora and Ivanovski (2018)	20	37	20	0	0 (0–6.0[b])
3	Barone et al. (2016)	30	84	37	2	0.8 (0.1–2.8)
4	Bonnet et al. (2018)	39	12	39	0	0 (0–9.5[b])
6	Cabello et al. (2013)	14	12	14	0	0 (0–26.3[b])
7	Cardaropoli et al. (2015)	26	12	26	0	0 (0–14.2[b])
8	Cardaropoli et al. (2019)	20	12	20	0	0 (0–18.4[b])
9	Chan et al. (2019)	18	12	18	0	0 (0–20.5[b])
11	Cosyn et al. (2011)	25	36	32	7	7.3 (2.9–15.0)
12	Cosyn et al. (2013)	28	33	28	0	0 (0–4.8[b])
13	Cosyn et al. (2016)	17	60	22	5	4.5 (1.5–10.6)
14	Crespi et al. (2018)	60	48	30	0	0 (0–3.1[b])
15	Cristalli et al. (2015)	24	12	25	2	8.0 (1.0–28.9)
16	D'Avenia et al. (2019)	20	16	20	0	0 (0–13.8[b])
19	Felice et al. (2015)	25	12	25	2	8.0 (1.0–28.9)
20	Fürhauser et al. (2016)	77	60	77	0	0 (0–1.0[b])
21	Ganeles et al. (2017)	11	24	15	0	0 (0–12.3[b])
22	Guarnieri et al. (2016)	25	36	12	0	0 (0–10.2[b])
23	Groenendijk et al. (2020)	98	12	98	0	0 (0–3.8[b])
24	Hartlev et al. (2014)	54	33	54	0	0 (0–2.5[b])
26	Kan et al. (2011)	35	48	35	0	0 (0–2.6[b])
28	Kniha et al. (2017)	16	12	16	0	0 (0–23.1[b])
30	Kolerman et al. (2017)	39	44.82	39	0	0 (0–2.5[b])
32	Ma et al. (2019)	16	60	17	0	0 (0–4.3[b])
34	Mangano et al. (2012)	26	24	26	0	0 (0–7.1[b])
35	Mangano et al. (2013)	40	31.09	22	0	0 (0–6.5[b])
36	Mangano et al. (2017)	103	36	42	0	0 (0–2.9[b])
42	Pieri et al. (2011), T: Platform switch abutment	19	12	19	1	5.3 (0.1–29.3)
44	Raes et al. (2018)	29	96	11	0	0 (0–4.2[b])
45	da Rosa et al. (2014)	18	58.56	18	0	0 (0–4.2[b])
49	Slagter et al. (2021)	40	60	18	0	0 (0–4.1[b])
55	Tortamano et al. (2010)	12	18	12	0	0 (0–20.5[b])
57	Valentini et al. (2010)	40	12	43	2	4.7 (0.6–16.8)
58	van Nimwegen et al. (2016)	51	48	51	2	1.0 (0.1–3.5)
60	Vidigal et al. (2017)	53	51	53	2	0.9 (0.1–3.2)

[a]Assuming poisson distributed failures.
[b]One-sided confidence interval.

TABLE 6 Survival of restorations – retention – failure rate and survival rates.

Retent. type	No. of studies	No. of imm. implants	Exp. time (years)	Failures	Failure rate[a] per 100 years	Survival rates[a]		
						1 year	3 years	5 years
Screw	6	105	309	5	1.0 (0.2–6.3)	99.0 (93.7–99.8)	97.0 (82.3–99.5)	95.0 (72.2–99.2)
Cement	23	725	2233	18	1.3 (0.6–3.0)	98.7 (97.0–99.4)	96.0 (91.3–98.2)	93.4 (85.9–97.0)

[a]Random-effects Poisson regression, screw versus cement: IRR (95% CI): 1.3 (0.2–7.2), $p = .743$.

TABLE 7 Surgical complications of implants – complication rate per study.

Study ID	Author (year)	Patients included	Immediate implants	No. of complications	Complications per 100 implants (95% CI)[a]
2	Arora and Ivanovski (2018)	20	40	2	5.0 (0.6–18.1)
3	Barone et al. (2016)	30	37	2	5.4 (0.7–19.5)
4	Bonnet et al. (2018)	39	39	0	0 (0–9.5[b])
5	Bruno et al. (2014)	12	36	5	13.9 (4.5–32.4)
6	Cabello et al. (2013)	14	14	0	0 (0–26.3[b])
7	Cardaropoli et al. (2015)	26	26	0	0 (0–14.2[b])
8	Cardaropoli et al. (2019)	20	20	0	0 (0–18.4[b])
9	Chan et al. (2019)	18	20	2	10.0 (1.2–36.1)
10	Cooper et al. (2014)	45	55	3	5.5 (1.1–15.9)
11	Cosyn et al. (2011)	25	32	0	0 (0–11.5[b])
12	Cosyn et al. (2013)	28	28	5	17.9 (5.8–41.7)
13	Cosyn et al. (2016)	17	22	7	31.8 (12.8–65.6)
14	Crespi et al. (2018)	60	30	0	0 (0–12.3[b])
15	Cristalli et al. (2015)	24	25	0	0 (0–14.8[b])
17	Degidi et al. (2014)	53	53	0	0 (0–7.0[b])
18	Esposito et al. (2015)	54	54	19	35.2 (21.2–54.9)
23	Groenendijk et al. (2020)	98	98	1	1.0 (0.0–5.7)
25	Hassani et al. (2021)	20	20	0	0 (0–18.4[b])
28	Kniha et al. (2017)	16	16	0	0 (0–23.1[b])
29	Kolerman et al. (2016)	34	34	2	5.9 (0.7–21.2)
31	Lombardo et al. (2016)	16	21	1	4.8 (0.1–26.5)
32	Ma et al. (2019)	16	28	9	32.1 (14.7–61.0)
33	Malchiodi et al. (2013)	58	64	0	0 (0–5.8[b])
34	Mangano et al. (2012)	26	26	0	0 (0–14.2[b])
35	Mangano et al. (2013)	40	22	0	0 (0–16.8[b])
37	Migliorati et al. (2015)	48	48	0	0 (0–7.7[b])
39	Noelken et al. (2018)	26	26	0	0 (0–14.2[b])
42	Pieri et al. (2011)	19	19	1	5.3 (0.1–29.3)
43	Puisys et al. (2022)	25	25	0	0 (0–14.8[b])
48	Sicilia-Felechosa et al. (2020)	40	40	1	2.5 (0.1–13.9)
51	Stoupel et al. (2016), Flapless	18	18	0	0 (0–20.5[b])
51	Stoupel et al. (2016), Flap	21	21	1	4.8 (0.1–26.5)
52	Sun et al. (2020)	30	30	0	0 (0–12.3[b])
56	Tsuda et al. (2011)	10	10	3	30.0 (6.2–87.7)
58	van Nimwegen et al. (2016)	51	51	2	3.9 (0.5–14.2)
59	van Nimwegen et al. (2018)	60	60	1	1.7 (0.0–9.3)
60	Vidigal et al. (2017)	53	53	2	3.8 (0.5–13.6)
62	Yoshino et al. (2014)	20	20	1	5.0 (0.1–27.9)

[a]Assuming Poisson distributed complications.

[b]One-sided confidence interval.

PES scoring by combining three less important parameters (facial contour, soft tissue color and texture) into one variable, resulting in only five parameters and a maximum possible score of 10. The WES index was also proposed by Belser et al. (2009) and focuses on the esthetic evaluation of an implant restoration. WES is based on five parameters, each also receiving a score between 0 and 2 for a maximum possible score of 10. These variables are tooth form, outline, color, surface texture, and translucency. Tettamanti et al. (2016) concluded in a comparison investigation of these and other esthetic indices that PES/WES and peri-implant–crown index (PICI) were

TABLE 8 Technical complications of restorations – complication rate per study.

ID	Author (year)	Patients included	Immediate loadings	Exposure time (years)	No. of complications	Complications per 100 years (95% CI)[a]
1	Arora et al. (2017)	30	30	117.5	0	0 (0–3.1[b])
2	Arora and Ivanovski (2018)	20	20	61.7	0	0 (0–6.0[b])
4	Bonnet et al. (2018)	39	39	39	0	0 (0–9.5[b])
6	Cabello et al. (2013)	14	14	14	5	35.7 (11.6–83.3)
8	Cardaropoli et al. (2019)	20	20	20	0	0 (0–18.4[b])
11	Cosyn et al. (2011)	25	32	96	1	1.0 (0.0–5.8)
13	Cosyn et al. (2016)	17	22	110	3	2.7 (0.6–8.0)
15	Cristalli et al. (2015)	24	25	25	0	0 (0–14.8[b])
18	Esposito et al. (2015)	54	35	35	4	11.4 (3.1–29.3)
19	Felice et al. (2015)	25	25	25	2	8.0 (1.0–28.9)
21	Ganeles et al. (2017)	11	15	30	0	0 (0–12.3[b])
23	Groenendijk et al. (2020)	98	98	98	1	1.0 (0.0–5.7)
25	Hassani et al. (2021)	20	20	20	0	0 (0–18.4[b])
26	Kan et al. (2011)	35	35	140	0	0 (0–2.6[b])
28	Kniha et al. (2017)	16	16	16	0	0 (0–23.1[b])
31	Lombardo et al. (2016)	16	20	38.8	3	7.7 (1.6–22.6)
32	Ma et al. (2019)	16	17	85	0	0 (0–4.3[b])
33	Malchiodi et al. (2013)	58	64	192	0	0 (0–1.9[b])
34	Mangano et al. (2012)	26	26	52	0	0 (0–7.1[b])
35	Mangano et al. (2013)	40	22	57	0	0 (0–6.5[b])
36	Mangano et al. (2017)	103	42	126	9	7.1 (3.3–13.6)
43	Puisys et al. (2022)	25	25	25	0	0 (0–14.8[b])
54	Tian et al. (2019)	27	30	30	1	3.3 (0.1–18.6)
60	Vidigal et al. (2017)	53	53	225.2	9	4.0 (1.8–7.6)
62	Yoshino et al. (2014)	20	20	20	2	10.0 (1.2–36.1)

[a]Assuming Poisson distributed complications.

[b]One-sided confidence interval.

TABLE 9 Biological complications of restorations – complication rate per study.

ID	Author (year)	Patients included	Immediate loadings	Exposure time (years)	No. of complications	Complications per 100 years (95% CI)[a]
1	Arora et al. (2017)	30	30	117.5	0	0 (0–3.1[b])
2	Arora and Ivanovski (2018)	20	20	61.7	2	3.2 (0.4–11.7)
3	Barone et al. (2016)	30	37	259	2	0.8 (0.1–2.8)
4	Bonnet et al. (2018)	39	39	39	0	0 (0–9.5[b])
6	Cabello et al. (2013)	14	14	14	0	0 (0–26.3[b])
8	Cardaropoli et al. (2019)	20	20	20	0	0 (0–18.4[b])
11	Cosyn et al. (2011)	25	32	96	0	0 (0–3.8[b])
13	Cosyn et al. (2016)	17	22	110	1	0.9 (0.0–5.1)
15	Cristalli et al. (2015)	24	25	25	0	0 (0–14.8[b])
17	Degidi et al. (2014)	29	53	106	3	2.8 (0.6–8.3)
18	Esposito et al. (2015)	54	35	35	2	5.7 (0.7–20.6)
21	Ganeles et al. (2017)	11	15	30	0	0 (0–12.3[b])
23	Groenendijk et al. (2020)	98	98	98	1	1.0 (0.0–5.7)
25	Hassani et al. (2021)	20	20	20	0	0 (0–18.4[b])
26	Kan et al. (2011)	35	35	140	0	0 (0–2.6[b])
28	Kniha et al. (2017)	16	16	16	0	0 (0–23.1[b])
31	Lombardo et al. (2016)	16	20	38.8	0	0 (0–9.5[b])

TABLE 9 (Continued)

ID	Author (year)	Patients included	Immediate loadings	Exposure time (years)	No. of complications	Complications per 100 years (95% CI)[a]
33	Malchiodi et al. (2013)	58	64	192	0	0 (0–1.9[b])
34	Mangano et al. (2012)	26	26	52	0	0 (0–7.1[b])
35	Mangano et al. (2013)	40	22	57	0	0 (0–6.5[b])
36	Mangano et al. (2017)	103	42	126	3	2.4 (0.5–7.0)
38	Noelken et al. (2011)	16	18	33	1	3.0 (0.1–16.9)
41	Paul and Held (2012)	26	31	105.4	0	0 (0–3.5[b])
43	Puisys et al. (2022)	25	25	25	0	0 (0–14.8[b])
51	Stoupel et al. (2016), Flapless	18	18	18	5	27.8 (9.0–64.8)
51	Stoupel et al. (2016), Flap	21	21	21	4	19.0 (5.2–48.8)
56	Tsuda et al. (2011)	10	10	10	1	10.0 (0.3–55.7)
57	Valentini et al. (2010)	40	43	43	2	4.7 (0.6–16.8)
62	Yoshino et al. (2014)	20	20	20	2	10.0 (1.2–36.1)

[a]Assuming Poisson distributed complications.

[b]One-sided confidence interval.

TABLE 10 Esthetic outcomes – weighted mean scores – meta-regression, random-effects model (REML).

	Month	No. of studies/ subgroups	Implants included	EWM	95% CI	I^2	τ^2
Papilla (mm)	0	11	303	−0.3	−0.5; −0.1	0.83	0.03
	1–6	26	566	−0.4	−0.5; −0.3	0.92	0.05
	12	37	866	−0.3	−0.4; −0.1	0.95	0.13
	18–24	4	54	−0.0	−0.7; 0.7	0.69	0.13
	33–44	8	306	0.3	−0.0; 0.6	0.86	0.11
	48–96	8	268	−0.1	−0.2; 0.0	0.62	0.02
PI	0	4	94	0.9	−1.2; 2.9	0.97	1.63
	1–6	4	136	2.1	1.8; 2.4	0.52	0.02
	12	6	244	1.6	0.1; 3.0	0.99	1.96
	48–96	3	71	2.7	2.4; 2.9	0.00	0.00
Midfacial	0	17	393	−0.5	−0.9; −0.1	0.96	0.56
	1–6	26	493	−0.5	−0.7; −0.3	0.91	0.16
	12	30	631	−0.3	−0.5; −0.2	0.96	0.13
	18–24	8	149	−0.4	−0.7; −0.2	0.83	0.07
	33–44	6	179	−0.2	−0.7; 0.4	0.93	0.26
	48–96	5	151	−0.3	−1.0; 0.4	0.96	0.29
PES (%)	0	15	417	73.2	66.4; 80.0	0.96	141.64
	1–6	11	306	83.1	78.9; 87.3	0.86	31.27
	12	19	583	83.1	79.2; 87.0	0.95	61.31
	18–24	9	167	79.1	73.9; 84.3	0.84	37.96
	33–44	7	150	81.7	75.7; 87.6	0.88	34.22
	48–96	9	281	76.9	71.8; 82.1	0.90	38.33
WES	0	7	246	6.2	4.6; 7.9	0.99	2.95
	1–6	5	182	8.2	7.1; 9.2	0.85	0.57
	12	3	158	7.5	6.0; 9.1	0.91	0.33
	18–24	5	111	8.2	7.0; 9.3	0.94	0.76
	33–44	4	98	7.9	7.0; 8.8	0.75	0.23
	48–96	4	153	8.3	6.3; 10.3	0.97	1.53

Abbreviation: EWM, estimated weighted mean.

TABLE 11A Papilla height (mm) – baseline and 12 month, Random-effects model (REML).

	Implants included	Baseline Mean, SD	12 month Mean, SD	Effect size[a] Hedges' *g* [95% CI]	Weight (%)
Cabello et al. (2013), mesial	14	−0.06, 0.49	−0.38, 0.68	−0.52 [−1.31, 0.26]	8.05
Cabello et al. (2013), distal	14	−0.19, 0.54	−0.8, 0.96	−0.76 [−1.56, 0.04]	7.99
Chan et al. (2019), mesial	18	0.3, 1	0.4, 1	0.10 [−0.58, 0.77]	8.43
Chan et al. (2019), distal	18	0.3, 1.3	0.5, 1.4	0.14 [−0.53, 0.82]	8.43
Pieri et al. (2011), T: Platform switch abutment, mesial	18	0, 0	−0.24, 0.21	−1.58 [−2.36, −0.80]	8.06
Pieri et al. (2011), T: Platform switch abutment, distal	18	0, 0	−0.28, 0.19	−2.04 [−2.88, −1.19]	7.84
Pieri et al. (2011), C: Conventional abutment, mesial	19	0, 0	−0.33, 0.19	−2.40 [−3.28, −1.53]	7.72
Pieri et al. (2011), C: Conventional abutment, distal	19	0, 0	−0.33, 0.23	−1.99 [−2.80, −1.17]	7.95
Zuiderveld et al. (2018), T: with CTG, mesial	29	−0.4, 0.7	−0.3, 0.7	0.14 [−0.38, 0.67]	8.88
Zuiderveld et al. (2018), T: with CTG, distal	29	−0.4, 0.6	−0.4, 0.7	0.00 [−0.52, 0.52]	8.89
Zuiderveld et al. (2018), C: without CTG, mesial	29	−0.3, 0.8	−0.4, 1	−0.11 [−0.63, 0.42]	8.89
Zuiderveld et al. (2018), C: without CTG, distal	29	−0.6, 0.7	−0.6, 0.6	0.00 [−0.52, 0.52]	8.89
Overall				−0.71 [−1.25, −0.17]	
$I^2 = 87.37\%$, $H^2 = 7.92$, $\tau^2 = 0.78$					

[a]Assuming a correlation of 0 between baseline and 12 month.

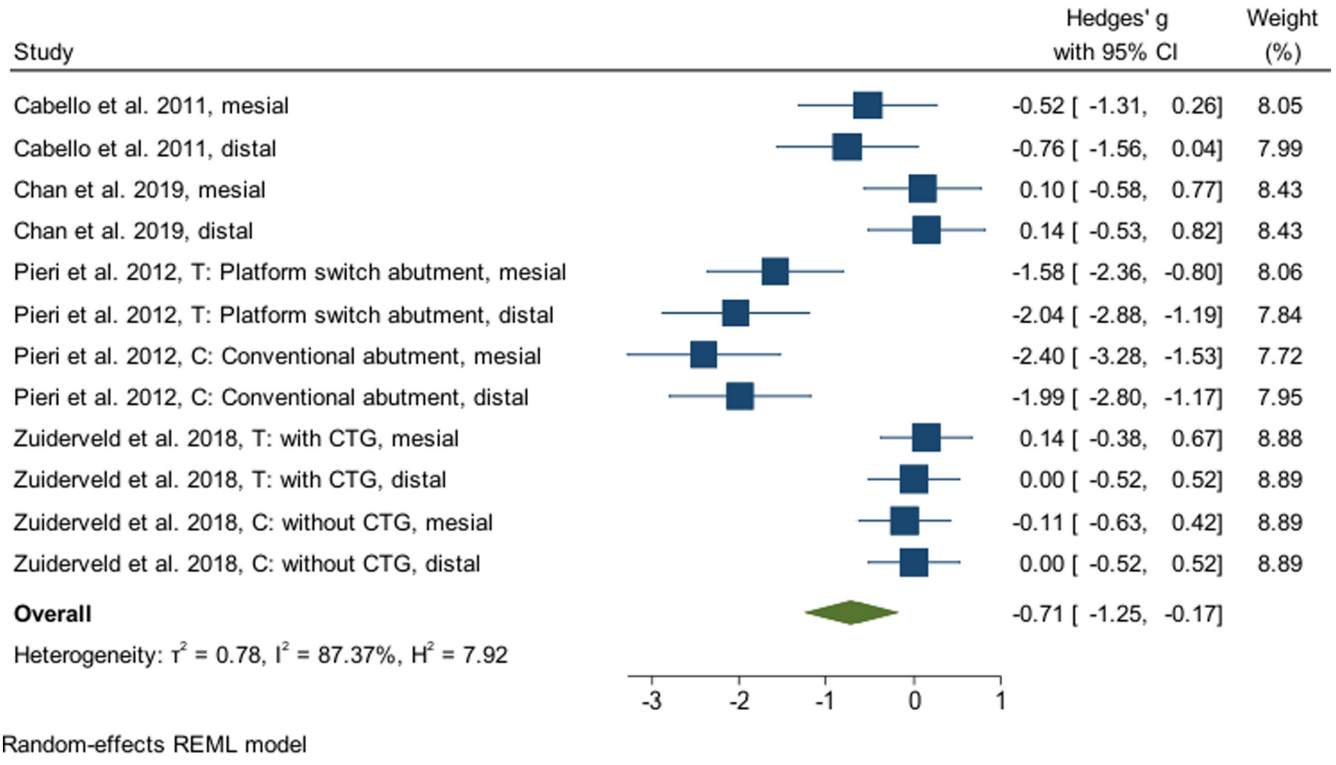

FIGURE 2 Forest plot: Papilla height (mm) – baseline and 12 month, random-effects model (REML).

TABLE 11B Midfacial – baseline and 12 month, Random-effects model (REML).

	Implants included	Baseline Mean, SD	12 month Mean, SD	Effect size[a] Hedges' *g* [95% CI]	Weight (%)
Cabello et al. (2013), mesial	14	−0.16, 0.4	−0.45, 0.25	−0.84 [−1.65, −0.03]	5.40
Chan et al. (2019), mesial	18	−0.2, 0.8	−0.1, 0.9	0.11 [−0.56, 0.79]	5.64
Ma et al. (2019), mesial	17	0, 0	0.36, 0.4	1.24 [0.48, 2.01]	5.48
Migliorati et al. (2015), CGT, mesial	24	−0.14, 0.36	−0.13, 0.44	0.02 [−0.55, 0.60]	5.79
Migliorati et al. (2015), CGT, distal	24	0, 0	−0.13, 0.24	−0.75 [−1.35, −0.15]	5.76
Migliorati et al. (2015), without CTG, mesial	24	−0.08, 0.29	−0.73, 0.51	−1.54 [−2.21, −0.88]	5.65
Migliorati et al. (2015), without CTG, distal	24	−0.18, 0.4	−0.24, 0.58	−0.12 [−0.70, 0.46]	5.79
Noelken et al. (2018), ABG	13	−1.8, 0.6	−0.8, 0.7	1.49 [0.56, 2.41]	5.19
Noelken et al. (2018), ABG + CTG	13	−2.3, 0.7	−0.3, 0.4	3.40 [2.08, 4.71]	4.41
Pieri et al. (2011), T: Platform switch abutment, mesial	18	0, 0	−0.61, 0.54	−1.56 [−2.34, −0.78]	5.46
Pieri et al. (2011), C: Conventional abutment, mesial	19	0, 0	−0.73, 0.52	−1.94 [−2.75, −1.14]	5.41
Puisys et al. (2022), mesial	25	0.2, 0.37	0, 0.1	−0.73 [−1.31, −0.14]	5.78
Spinato et al. (2012), Bone graft	22	−0.23, 0.53	−0.4, 0.6	−0.29 [−0.90, 0.31]	5.74
Spinato et al. (2012), No Bone graft	23	−0.15, 0.32	−0.3, 0.36	−0.43 [−1.03, 0.17]	5.76
Tian et al. (2019)	27	−0.26, 0.41	−0.24, 0.37	0.05 [−0.49, 0.59]	5.84
Tsuda et al. (2011), mesial	10	−2.2, 0.59	−2.25, 1.21	−0.05 [−0.98, 0.88]	5.18
Zuiderveld et al. (2018), T: with CTG, mesial	29	0.1, 0.9	0.1, 0.8	0.00 [−0.52, 0.52]	5.87
Zuiderveld et al. (2018), C: without CTG, mesial	29	−0.5, 1	−0.5, 1.1	0.00 [−0.52, 0.52]	5.87
Overall				−0.15 [−0.66, 0.36]	
$I^2 = 90.47\%$, $H^2 = 10.49$, $\tau^2 = 1.08$					

[a]Assuming a correlation of 0 between baseline and 12 month.

significantly more reproducible than the traditional implant crown aesthetic index.

This meta-analysis only included clinical studies with data available for esthetic outcome indices. Not all studies included baseline information; however, an effect size comparison was performed with Hedges' *g* and estimated a loss of papilla height (−0.71 mm) between baseline and 12 months, midfacial recession of −0.15 mm, and a gain of 0.82 in PES. The loss of papilla height and minor midfacial recession are influenced by the local alveolar anatomy following tooth extraction. Dimensional changes following tooth extraction can occur and have been described as the "bundle bone effect" (Araújo et al., 2005; Misawa et al., 2016). Ridge alteration and bone remodeling processes occur exactly in the first 12 months. However, there was an increase in PES, which may suggest that although these bone modifications occur, they are not clinically evident. Individual characteristics of each study were documented, and groups were created to measure the influence of treatment approaches within the esthetic outcome results. Data regarding flap versus no flap, type of implant (parallel-walled/tapered walled), implementation of a soft tissue procedure, and the implant connection were extracted. Today, the flapless approach is advantageous because it maintains the vascular supply to the peri-implant mucosa; however, flap use offers the possibility of implementing bone or contour augmentation procedures and provides better access. In the present investigation, the presence or absence of a flap, implementation of soft tissue procedures, and implant connection type had no influence on the result of the included esthetic outcome indices. Only the implant type had a statistically significant influence on WES, favoring a parallel-walled implant type.

Reduced treatment time and fewer dental appointments, no need for removable provisional prostheses, and patient expectations have encouraged the combined treatment of immediate implant insertion and loading in oral implantology. Future studies should be designed using validated and standardized esthetic indices assessed before treatment, immediately after completion of treatment, and repeated at regular follow-up intervals to accurately gauge the treatment outcome from an esthetic point of view and provide long-term success for patients.

Considering the limitations of the present review, the chosen languages were those that reviewers could speak, read, and write correctly. Although this could be a potential limitation, some authors have been suggested that the English language is sufficient for systematic reviews; nevertheless, the use of other languages may widen the scope of possible studies to be included (Morrison et al., 2012).

Another limitation was the present heterogeneity of different study types that were included (randomized and controlled clinical trials, cross-sectional studies, cohort studies, case–control studies, case series); therefore, a supplement analysis was performed only including RCT studies that have a lower risk of bias.

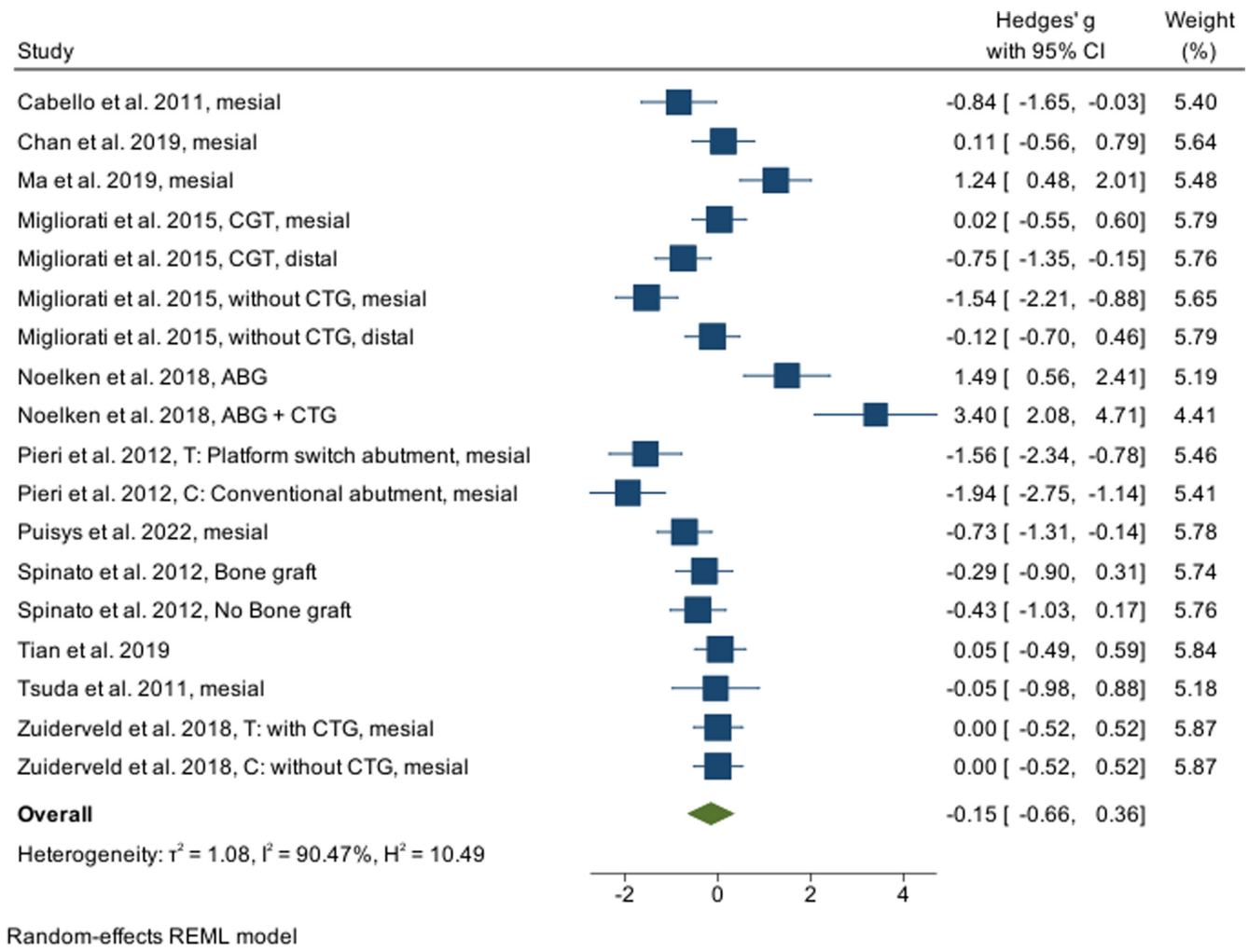

FIGURE 3 Forest plot: Midfacial – baseline and 12 month, random-effects model (REML).

TABLE 11C PES (%) – baseline and 12 month, Random-effects model (REML).

	Implants included	Baseline Mean, SD	12 month Mean, SD	Effect size[a] Hedges' *g* [95% CI]	Weight (%)
Bonnet et al. (2018)	39	56.5, 14.2	70.7, 13.3	1.02 [0.54, 1.50]	14.05
Cardaropoli et al. (2015), mesial	26	84.1, 8.9	81.8, 10.4	−0.23 [−0.79, 0.32]	13.33
Cardaropoli et al. (2019), mesial	20	87.5, 8.9	89.6, 7.1	0.26 [−0.38, 0.90]	12.54
D'Avenia et al. (2019), mesial	20	48.2, 12.5	63.6, 8.6	1.41 [0.69, 2.13]	11.78
Groenendijk et al. (2020)	98	70.5, 17.1	86.3, 11.7	1.07 [0.77, 1.38]	15.51
Noelken et al. (2018), ABG	13	73.6, 10.7	88.6, 8.6	1.50 [0.57, 2.42]	9.89
Noelken et al. (2018), ABG + CTG	13	62.1, 18.6	85.7, 6.4	1.64 [0.69, 2.59]	9.69
Puisys et al. (2022), mesial	25	88.6, 9.4	91.4, 8.5	0.31 [−0.26, 0.88]	13.21
Overall				0.82 [0.37, 1.28]	
I^2 = 79.93%, H^2 = 4.98, τ^2 = 0.33					

[a]Assuming a correlation of 0 between baseline and 12 month.

Although the data analysis was performed by time stratification considering the short-, medium- and long-term follow-up, it should be noted that the follow-up heterogeneity may limit the obtained results. These limitations should be considered when the results shall be applied for further subjects.

5 | CONCLUSION

Immediate implant placement and immediate loading in the maxillary esthetic zone presents excellent clinical performance by means of high survival rates for both implants and reconstructions, and

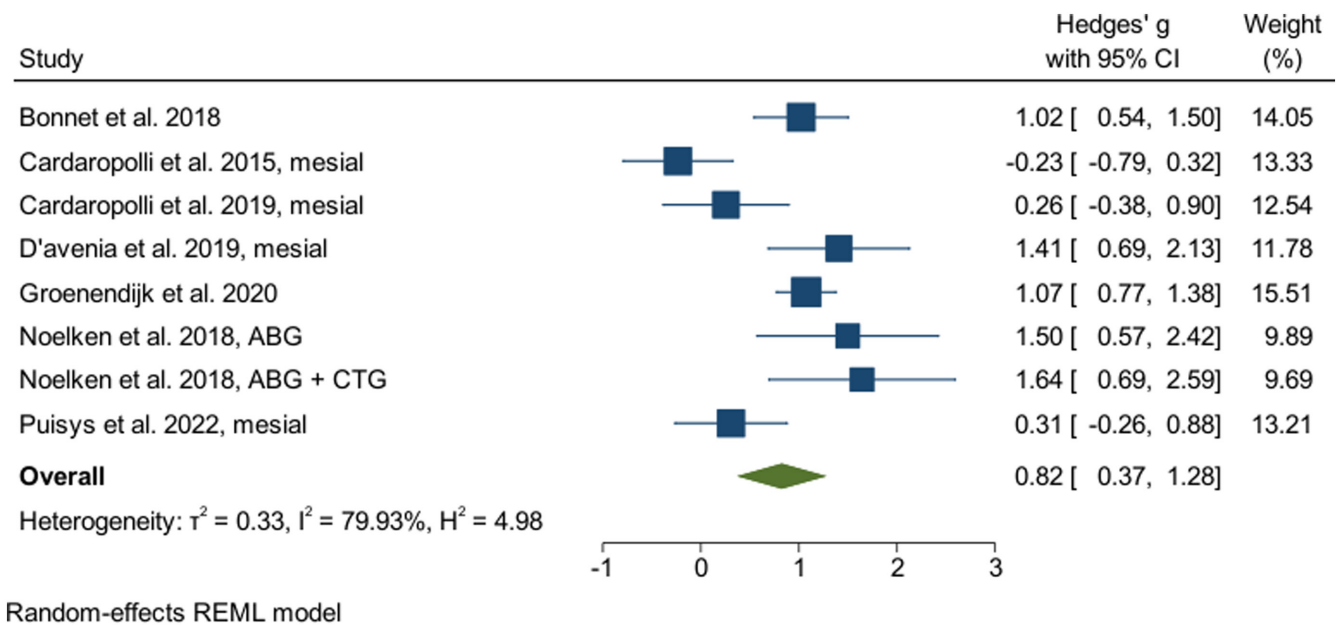

FIGURE 4 Forest plot: PES (%) – baseline and 12 month, random-effects model (REML).

TABLE 12 Esthetic outcomes – weighted mean scores in groups.

	Studies/Subgroup	Implants included	Weighted mean[a]	95% CI[a]	*p*-value[a]
Papilla (mm)					
Flap					
Flapless	9	182	−0.1	−0.6; 0.4	
Flap	3	94	−0.1	−3.9; 3.6	
Difference			−0.2	−0.8; 0.4	.494
Type of implant					
Parallel-walled	3	60	−0.1	−10.6; 10.4	
Tapered-walled	5	87	0.3	−0.5; 1.0	
Difference			−0.2	−1.1; 0.7	.601
Midfacial					
Type of implant					
Parallel-walled	3	54	−1.2	−14.1; 11.8	
Tapered-walled	7	139	−0.1	−0.4; 0.2	
Difference			0.6	−0.5; 1.7	.235
Soft tissue procedure					
No	7	168	−0.5	−1.2; 0.2	
Yes	5	101	−0.5	−1.8; 0.8	
Difference			0.0	−1.1; 1.1	.999
PES (%)					
Flap					
Flapless	23	697	76.2	70.5; 81.9	
Flap	8	219	80.0	70.3; 89.8	
Difference			2.9	−6.0; 11.8	.510
Type of implant					
Parallel-walled	11	293	80.3	75.6; 85.0	
Tapered-walled	11	361	73.3	63.8; 82.9	
Difference			−1.6	−6.4; 3.3	.507

TABLE 12 (Continued)

	Studies/Subgroup	Implants included	Weighted mean[a]	95% CI[a]	*p*-value[a]
Soft tissue procedure					
No	4	93	72.0	62.5; 81.6	
Yes	5	138	73.4	53.6; 93.2	
Difference			3.3	−11.8; 18.4	.610
Implant connection					
Internal hex	5	170	80.0	69.8; 90.3	
Conical hex	5	209	63.9	40.8; 87.0	
Difference			−6.8	−28.1; 14.5	.474
WES					
Flap					
Flapless	11	410	6.4	5.0; 7.9	
Flap	5	126	8.4	5.5; 11.3	
Difference			1.1	−0.8; 2.9	.230
Type of implant					
Parallel-walled	7	182	7.8	6.7; 8.9	
Tapered-walled	6	243	5.6	2.9; 8.3	
Difference			−1.8	−3.6; −0.0	.049
Implant connection					
Internal hex	4	144	7.6	4.7; 10.5	
Conical hex	3	139	4.5	1.8; 7.3	
Difference			−1.2	−6.1; 3.8	.548

[a]Meta-analysis regression adjusted for time, Random-effects model (REML).

therefore it can be concluded as a viable treatment option under specific conditions. These conditions are healthy adjacent teeth, intact facial bone, no acute infection present, ability to place the implant in the correct 3-dimensional position for an optimal restoration, and anticipated primary stability of the implant to allow immediate restoration.

Another conclusion was that esthetic outcome measured by individual parameters resumed stable results over time.

AUTHOR CONTRIBUTIONS

Julia-Gabriela Wittneben, Pedro Molinero-Mourelle and Adam Hamilton were involved in the concept and design of the study, data collection, analyzed and interpreted data, drafted the article and approved the final version of the manuscript; Barbara Obermaier and Muhsen Alnasser were involved in the data collection and approved the final version. Dean Morton, German O. Gallucci and Daniel Wismeijer were involved in the concept and design of the study, data analysis, critical revision of the manuscript and approved the final version.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

None declared.

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SUPPORTING INFORMATION

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

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