

REVIEW ARTICLE OPEN ACCESS

Patient-Reported and Clinician-Reported Esthetic Outcomes at Implant Sites Are Not Associated: A Systematic Review With Individual Participant Data Meta-Analysis

Sofya Sadilina¹  | Nicolas P. A. Müller^{1,2}  | Franz J. Strauss^{1,3}  | Ronald E. Jung¹  | Daniel S. Thoma^{1,2}  | Stefan P. Bienz¹ 

¹Clinic for Reconstructive Dentistry, University of Zurich, Zurich, Switzerland | ²Department of Periodontology, Research Institute for Periodontal Regeneration, Yonsei University College of Dentistry, Seoul, Republic of Korea | ³Universidad Autonoma de Chile, Santiago, Chile

Correspondence: Daniel S. Thoma (daniel.thoma@zzm.uzh.ch)

Received: 15 November 2024 | **Revised:** 25 July 2025 | **Accepted:** 30 July 2025

Funding: The project was self-funded by the Clinic for Reconstructive Dentistry from the University of Zurich.

Keywords: clinician-reported outcomes | dental implants | dentistry | esthetic outcomes | patient-reported outcomes | systematic review

ABSTRACT

Objectives: This systematic review aimed to determine whether patient-reported outcomes (PROs) are associated with clinician-reported outcomes (ClinROs) in terms of esthetics in patients with single implant-supported crowns in the esthetic region.

Methods: A systematic electronic search was conducted following a pre-established protocol to identify randomized controlled trials (RCT) involving patients with single implant-supported crowns in the esthetic region. Studies had to assess both patient- and clinician-reported outcomes. A two-stage individual participant data (IPD) meta-analysis was conducted. First, each study was analyzed separately to obtain correlation coefficients. Second, these estimates were pooled using a random-effects restricted maximum likelihood (REML) model.

Results: A total of 29 RCTs evaluating 1414 implant-supported crowns were included, with IPD available for 14 trials evaluating 675 patients. At crown insertion, IPD meta-analysis from 171 patients across four RCTs showed no significant correlations ($r=0.11$, 95% CI $[-0.04; 0.27]$, $p=0.16$) between pink esthetic score (PES) and patient satisfaction with esthetics assessed with visual analogue scale (VAS). At the 1-year follow-up, IPD from 502 patients in 11 studies showed a negligible positive correlation ($r=0.09$, 95% CI $[-0.00; 0.18]$, $p=0.06$) between PES or modified PES and VAS esthetic satisfaction. At 10-year follow-up, data from 80 patients in two studies showed no correlation between modified PES and VAS patient satisfaction ($r=-0.05$, 95% CI $[-0.37; 0.27]$, $p=0.75$). Regarding white esthetic score (WES) and VAS satisfaction, data from 376 patients in seven studies showed no significant correlations at the 1-year follow-up ($r=0.03$, 95% CI $[-0.08; 0.13]$, $p=0.60$).

Conclusion: Clinician-reported outcomes, using PES and WES, showed no correlation with patient-reported esthetic satisfaction, regardless of the follow-up duration.

Trial Registration: PROSPERO number CRD42023394920

1 | Introduction

Within the last two decades, the value of esthetic outcomes significantly increased in medical and dental fields, and esthetic

assessments became a criterion to rate treatment success (Cosyn et al. 2017; Pjetursson et al. 2014). For current treatments, the goal is to create implant-supported restorations resembling natural teeth, including the surrounding soft tissues (Studer

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2025 The Author(s). *Clinical Oral Implants Research* published by John Wiley & Sons Ltd.

et al. 1996; Sadilina et al. 2024). Nevertheless, little is known about whether the clinicians' esthetic evaluations align with patient perceptions (Cosyn et al. 2017).

Esthetic assessments at implant sites can be categorized into metric parameters (e.g., mid-facial recession measured in millimetres) and esthetic indexes (e.g., Pink Esthetic Score [PES]) (Cosyn et al. 2022). Among these indexes, PES is the most well-known to assess esthetics around a dental implant. As a clinician-reported outcome (ClinROs), PES has demonstrated favorable reliability and consistency across different studies, aiming to provide reproducible data (Hof et al. 2018). However, the association between PES and patients' perception remains unclear. Esthetic parameters are challenging to assess, and even validated esthetic indices have rarely achieved exact reproducibility. Moreover, subjective factors could be influenced by the patient's and clinician's expectations (Bienz et al. 2022). Previous studies have indicated a discrepancy between clinicians and patients, with the latter tending to be less critical of aesthetic outcomes (Thoma et al. 2024; Meijndert et al. 2007). It is presumed that patient expectations and psychological factors influence this discrepancy, yet robust evidence supporting this assumption is limited.

To address this, patient-reported outcomes (PROs) are increasingly used in treatment selection and outcome assessment, especially in cases with high esthetic demands. PROs are measured by patient-reported outcomes measures (PROMs) (Powers 3rd et al. 2017). PROMs are questionnaires to assess subjective patient's perception regarding various aspects of their health and the impact of a disease or its treatment on quality of life (McGrath et al. 2012). PROMs represent an average of what patients value, and they are becoming a decisive factor for treatment planning (Thoma and Strauss 2022). Given that esthetic expectations depend on the tooth position and visibility during smiling, PROMs are particularly valuable in the esthetic zone, where patient's subjective evaluation comes first.

However, the data from objective and subjective criteria may differ. Little investigation has been done so far to verify whether the objective parameters obtained by clinicians coincide with the perception of the patient. To summarize the variety of esthetic outcomes, including secondary outcomes, the present systematic review gathered data reporting PROMs and ClinROs from the same patient. Given the limitations of previous meta-analyses using aggregated data in related fields, an individual participant data (IPD) meta-analysis is warranted (Riley et al. 2010). IPD offers several advantages. First, pooling individual-level data allows the extraction of esthetic outcomes that may have been reported only as secondary or additional outcomes, thereby increasing statistical power. Second, IPD reduces aggregation bias, and the larger number of participant-level data points enables a more comprehensive assessment of individual-level cofactors.

Therefore, the aim of the present systematic review and IPD meta-analysis of randomized controlled trials was to assess the association of PROs and ClinROs on the esthetics of implant-supported restorations in the esthetic region.

2 | Material and Methods

2.1 | Protocol and Registration

This manuscript was reported according to the Preferred Reporting Items for Systematic review and Meta-Analysis of Individual Participants Data (PRISMA-IPD) (Stewart et al. 2015) and the 2021 Cochrane collaboration guideline (Higgins et al. 2021). A detailed protocol was designed before the start of this review and prospectively registered on the International Prospective Register of Systematic Reviews (PROSPERO ID: CRD42023394920). Ethical approval was not required for this meta-analysis; although each of the included studies was approved by the institutional ethics committee of the participating site.

2.2 | Terminology

Because of the heterogeneity in the terminology reported in the existing literature, the following definitions were used according to the Cochrane Handbook for Systematic Reviews of Interventions (Johnston et al. 2019).

Patient-reported outcome (PRO) is "any report of the status of a patient's health condition that comes directly from the patient without interpretation of the patient's response by a clinician or anyone else" (U.S. Food and Drug Administration, F 2021b).

Clinician-reported outcomes (ClinROs) are "measurements based on a report that comes from a trained health-care professional after observation of a patient's health condition" (U.S. Food and Drug Administration, F 2021a). Most ClinROs measures involve a clinical judgment or interpretation of the observable signs, behaviors, or other manifestations related to a disease or condition (FDA-NIH Biomarker Working Group 2016; BEST (Biomarkers, EndpointS, and other Tools)). In this systematic review, ClinROs were evaluated with the scope of objective indexes and subjective factors related to the clinician's perception of esthetics.

2.3 | Participants-Intervention-Outcome-Study Design (PIOs)

The eligibility criteria of the current systematic review were organized by the modified PICO acronym, excluding the "comparison" element, and were aimed to answer the following focused question: "In patients with an implant-supported crown in the esthetic region, are patient-reported outcomes associated with clinician reported outcomes in terms of esthetic outcomes?"

- Population: Partially edentulous adult patients with at least one implant-supported crown surrounded by neighboring teeth in the esthetic region.
- Intervention: An implant-supported crown that has been rated in regard to satisfaction and esthetics by the patient as well as the clinician or professional examiner.
- Outcomes: Patient-reported outcome, measured with Visual Analogue Scale (VAS), NRS (Numeric Rating Scale), OHIP

(Oral Health Impact Profile) or other types of standardized questionnaires with more than a 3-point scale; and clinician-reported outcomes, measured with Pink Esthetic Score (PES), White Esthetic Score (WES), VAS, mid-facial recession, color measurements, or other types of standardized esthetic indices.

- Study design: Only randomized controlled trials (RCT) either with parallel or split-mouth design were evaluated to maintain consistency in quality assessment criteria and to

reduce potential risk of bias. No studies were excluded on the basis of publication date, publication status (ahead to print) or number of included patients.

We assessed study eligibility criteria based on the PIO framework (Table 1). All decisions regarding the eligibility criteria were made by the group of review authors, including dentists with professional experience in prosthetic and implant dentistry.

TABLE 1 | Summary of review search strategy and eligibility criteria.

Databases	1. Medline (via Pubmed) 2. Embase 3. Web of Science
Registers	Cochrane central register of controlled trials (CENTRAL)
Other sources	Forward and backward reference checking from reviewed papers and relevant systematic reviews on the topic
Key terms	Population (P): (dental implants) OR (dental implantation) OR (dental prosthesis, implant-supported) AND (patient reported outcome measures) OR (PROMS) OR (patient satisfaction) OR (patient expectation) OR (patient centered outcome) OR (patient opinion) OR (patient-reported) OR (patient related) OR (visual analog scale) OR (VAS) OR (quality of life) OR (numerical rating scale) OR (OHIP) OR (Questionnaire) AND (clinician reported outcomes) OR (operator reported outcome measures) OR (esthetics, dental) OR (aesthet*) OR (pink esthetic score) OR (PES) OR (white esthetic score) OR (WES) OR (esthetic outcomes) OR (esthetic index) OR (visual analog scale) OR (VAS).
Limits	
Dates	Any publication date until search period
Language	English, German, Spanish, Russian
Location	International
Article type	Peer reviewed articles
Eligibility criteria	
Types of studies	Only RCTs. Methodological quality—not used as an exclusion criterion but considered when synthesizing the evidence for all studies.
Inclusion	Population: Systematically health patients, older than 18 years and with presence of at least one implant-supported fixed dental restoration in the esthetic region (15–25); Intervention: An implant-supported crown that has been rated in regards to satisfaction and esthetics by the patient as well as clinician or professional examiner; Outcome: PROMs, measured with VAS, NRS, OHIP or other types of standardized questionnaires with more than a 3-point scale and ClinROs, measured with PES, WES, VAS, mid-facial recession, color measurements or other type of standardized esthetic indices; Study design: only RCT, either with parallel or split-mouth design.
Exclusion	(1) Unsuitable population (not evaluating single implant-supported crown surrounded by neighbouring teeth in the maxillary esthetic region); (2) Not evaluating PROMs measured by more than a 3-point scale or 3-item standardized questionnaire; (3) Not evaluating esthetic outcomes; (4) Evaluating PROMs and ClinROs registered in different time points; (5) Inadequate study type (not RCT); (6) Articles reported not in English, German, Spanish or Russian; (7) Trial registered, not yet published; (8) Trial of published and included articles.
Search date	January 20, 2025

Abbreviations: ClinROs, clinician-reported outcomes; NRS, numerical rating scale; OHIP, oral health impact profile; PES, pink esthetic score; PROMs, patient reported outcome measurements; RCT, randomized controlled trial; VAS, visual analogue scale; WES, white esthetic score.

2.4 | Search Strategy

Two review authors (SS and FS) conducted in duplicate electronic searches in MEDLINE (searched via PubMed), The Cochrane Central Register of Controlled Trials, Embase, and Web of Science up to January 20, 2025. The search strategy was designed and adapted to each type of database (Table S1). No search filters were applied. In addition, cross-reference checks were conducted within the bibliographies of all the included studies and within the relevant reviews on the topic (De Bruyn et al. 2015; Wittneben et al. 2018; Wittneben et al. 2023; Younes et al. 2018).

2.5 | Study Selection

Based on the inclusion and exclusion criteria (Table 1), two reviewers (SS and NM) independently screened all titles and abstracts using the Rayyan Online Software (Qatar Computing Research Institute), while the first 100 abstracts were discussed for calibration purposes prior to formal selection. No restrictions were made in terms of study duration, but the language was restricted to English, German, Spanish, and Russian. Any disagreement between the two reviewers was discussed and resolved by a third review author (SB). Subsequently, the same authors conducted a full-text analysis of studies identified as potentially eligible, after calibration of the first five articles. Any conflicts were resolved by a third review author (SB). The inter-agreement between reviewers was quantified using Cohen's Kappa score.

2.6 | Data Extraction

Corresponding authors of the included articles were contacted by e-mails and were kindly asked to provide a table with the raw data for all the patients regarding utilized PROMs and ClinROs. A second e-mail was sent after 2 weeks. For the included studies of which raw data was not available, means and standard deviations were extracted from the publication. For each eligible trial, two reviewers (SS and NM) extracted the data independently without modifications using a standardized, pilot-tested data extraction table (Excel Microsoft Corporation) after calibration. In cases of multiple publications from trials evaluating the same cohort, the information was extracted from all the reports directly into a single data collection form and followed a two-step approach. The general characteristics (e.g., study type, population characteristics) were obtained once from the primary study, and the specific outcomes (e.g., ClinROs assessment in different time points) were extracted from all relevant publications, including different follow-up periods.

2.7 | Assessment of Risk of Bias and Quality of Evidence

For each included study, two authors (SS and NM) independently used the risk of bias assessment for randomized controlled trials tool 2 (ROB-2) from the current version of the Cochrane handbook (Sterne et al. 2019). In case of disagreement, both reviewers reached agreement on any assessment, resolved by the third author (FS).

The quality of evidence for each estimated effect size was evaluated using GRADE guidelines (Schunemann et al. 2008), considering factors such as inconsistencies in studies results, indirectness of evidence, and study imprecision. The findings were summarized in a GRADE evidence profile table. The GRADE guidelines were used to categorize heterogeneity, with <40% indicating low, 30%–60% representing moderate, 50%–90% signifying substantial, and 75%–100% reflecting considerable heterogeneity (Guyatt et al. 2011).

2.8 | Data Synthesis

The descriptive and qualitative aspects of the included studies were summarized, covering factors such as RCT type, population characteristics, type of augmentation, evaluated timepoints, and details on patient and clinician-reported outcome measures. To ensure analytical consistency, patient-reported outcome measures utilizing different measuring units were standardized prior to statistical analysis (e.g., 10 cm VAS scale were converted to 100 mm).

2.9 | Data Analysis

For this meta-analysis, we conducted a two-stage individual participant data (IPD) meta-analysis. In the first stage, each study was analyzed separately to obtain correlation coefficient estimates and their variances (Burke et al. 2017). Spearman correlation coefficients were calculated from the original raw data. In the second stage, we pooled the correlation estimates across studies using a random-effects via Restricted Maximum Likelihood (REML) model to account for potential heterogeneity (Poepl et al. 2007; Veroniki et al. 2016). To ensure valid inference, Fisher's Z transformation was applied before pooling, as it approximates a normal distribution, which is essential when combining correlation estimates (Rosner and Glynn 2007). This approach allowed us to compute 95% confidence intervals and pooled effect estimates while minimizing bias from non-normality in correlation distributions.

If a study examined the correlation between PROMs and more than one scale (e.g., PES or modified PES) a subgroup analysis was performed.

2.10 | Subgroup and Heterogeneity Analysis

Subgroup analyses were conducted to examine the impact of follow-up time on correlations. We assessed between-study heterogeneity by calculating the Q statistic, derived from the chi-squared test, and the inconsistency index (I^2). A threshold of $I^2 > 50\%$ was set to indicate significant heterogeneity, with a p -value < 0.10 considered statistically significant. The τ^2 value of 0.01 suggests a small amount of variance in effect sizes between studies (Higgins and Thompson 2002).

A correlation coefficient was considered between 0.0 and 0.09 to be negligible, 0.10 and 0.39 to be weak, 0.40 and 0.69 to be moderate, 0.70 and 0.89 to be strong, and 0.90 and 1.0 to be a very strong correlation (Schober et al. 2018). All analyses were conducted using STATA version 18.5 (StataCorp, College Station, TX).

3 | Results

3.1 | Search

The initial search yielded 5789 publications, of which 1427 were retrieved from Medline (via PubMed), 1532 entries from Embase, 1518 trials from CENTRAL, and 1312 studies via Web of Science. After excluding 1956 duplicates, the total number of entries was 3833. Of these, 3580 were discarded after reviewing the titles and abstracts. In total, 253 publications were selected for full-text analysis, while 211 were excluded during this stage (the list of excluded studies and corresponding reasons were reported in Table S2). No additional studies were identified through cross-reference checking. The inter-rater agreement during the title and abstract screening phase was substantial agreement between reviewers ($k=0.74$, agreement 84%), and it remained high during the full-text analysis phase ($k=0.84$, agreement 90%). Finally, 42 articles reporting on 29 unique patient populations were included (Figure 1).

Table 2 summarizes the general details, participant information, and implant characteristics of the included studies. Overall, 1414 patients and 1414 implant-supported crowns were part of

the analysis. According to the summary of the quality assessment by the ROB-2 tool, 27 articles showed a low risk of bias; 12 demonstrated some concerns; and three studies showed a high risk of bias (Figure 2). Ten RCTs revealed some concerns related to the bias in the measurement of the outcome (domain 4). Three studies had some concerns associated with the randomization process (domain 1) and one trial due to deviations from intended interventions (domain 2). Four RCTs demonstrated some concerns because of missing outcome data (domain 3); most of them were the long-term follow-ups of the original trial.

3.2 | Characteristics of the Included Studies

The included articles were published between 2007 and 2024. All RCTs had parallel design, and 22 studies included two arms, and seven trials investigated three arms. Ten articles were a follow-up of previously published trials, with the investigated period from 1 to 5 years.

From the total of 1414 treated patients, 776 (54.9%) were females, 578 (40.9%) were males, and the gender of the remaining

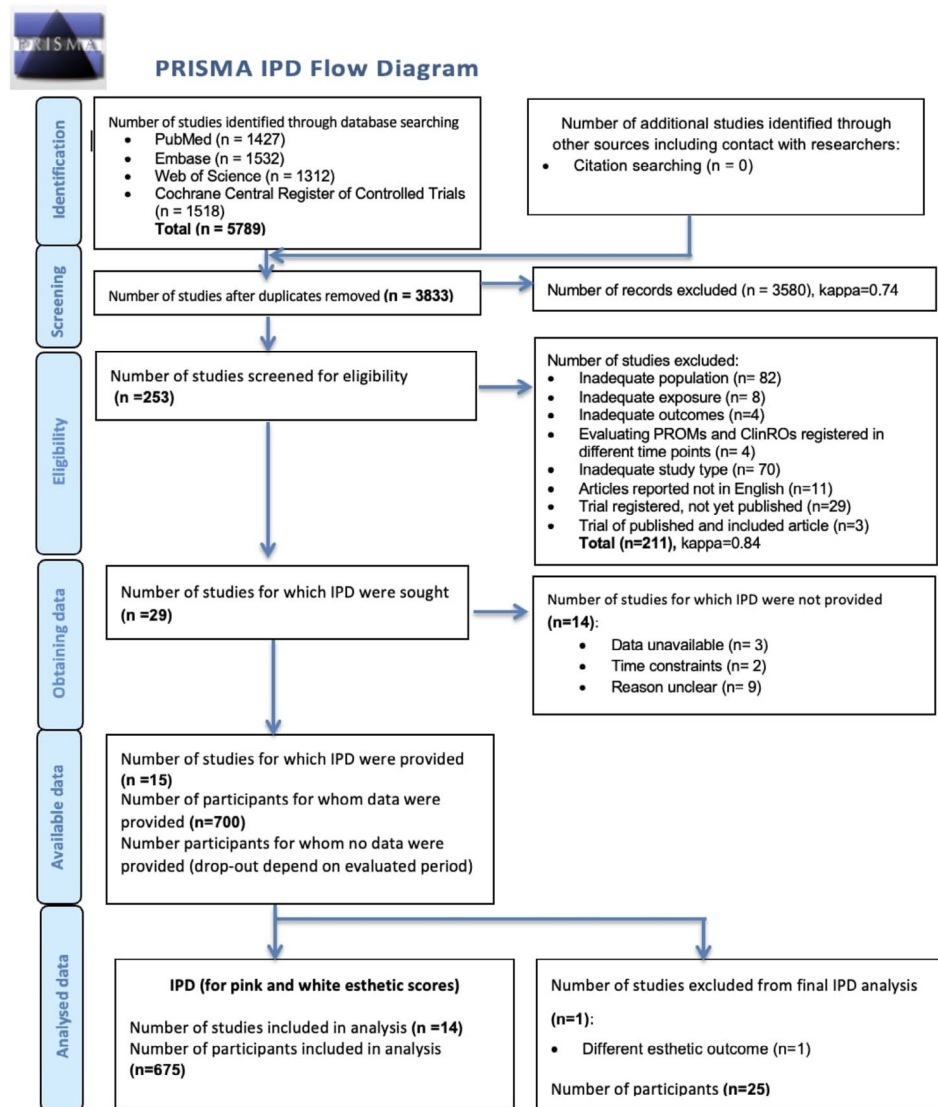


FIGURE 1 | PRISMA-IPD flow chart for the review. IPD, individual patient data.

TABLE 2 | Characteristics of the included studies—Participants and implants.

N	Study/Country	RCT type	Participants			Implants		
			Number of patients (implants)	Age, years, mean [SD] (range)	Gender (male/female)	Type of intervention	Type of augmentation	Implant brand
1	Atef et al. 2021 / Egypt	Two arms, parallel	42 (42)	36 [5.5]	10/30	Intervention-1: socket shield; Intervention-2: GBR with xenograft	Intervention-2: bone	ISII, Neobiotech
2	de Beus et al. 2024 / Netherlands	Two arms, parallel	49 (49)	Intervention-1: 52.4 (23.1–72.5) Intervention-2: 52.1 (28.1–76.3)	24/25	Intervention-1: titanium impl Intervention-2: zirconia impl	No	One arm: Straumann Pure, Straumann; Second arm: SLActive, Straumann BL RC, Straumann
3	Borgia et al. 2022 / Uruguay	Two arms, parallel	31 (31)	Intervention-1: 51.8 [10.9] Intervention-2: 55.6 [11.8]	10/21	Intervention-1: GBR with autologous bone from tuberosity; Intervention-2: GBR with DBBM	Bone	Ossotite Certain prevail, Biomet 3i
4	Canullo et al. 2016 / Spain	Two arms, parallel	30 (30)	58.2 (31–79)	18/12	Intervention –1: cleaning protocol by steaming Intervention-2: plasma of argon treatment	No	Premium SP Implants, Sweden & Martina
5	Carrillo de Albornoz et al. 2014 ; Ferrantino et al. 2023 / Spain	Two arms, parallel	25 (25)	Intervention-1: 51.8 [10.9] Intervention-2: 51.6 [8.9]	11/15	Intervention-1: titanium abutment Intervention-2: zirconia abutment	No	Element RC; Thommen Medical AG
6	Cosyn et al., 2021 ; Cosyn et al. 2022 ; Surdiacourt et al. 2024 /Belgium	Two arms, parallel	60 (60)	Intervention-1: 50.1 [17.0] Intervention-2: 48.2 [16.3]	29/31	Intervention-1: soft tissue augmentation with CTG Intervention-2: soft tissue augmentation with CMX	Soft tissue	Nobel Replace, Nobel Biocare
7	De Bruyckere et al. 2020 /Belgium	Two arms, parallel	40 (40)	Intervention-1: 51.0 [13.0] Intervention-2: 48.0 [15.0]	21/19	Intervention-1: Imp placement and GBR Intervention-2: Impl placement and CTG	Intervention-2: soft tissue; Intervention-1: bone	NobelActive, Nobel Biocare

(Continues)

TABLE 2 | (Continued)

N	Study/Country	RCT type	Participants			Implants		
			Number of patients (implants)	Age, years, mean [SD] (range)	Gender (male/female)	Type of intervention	Type of augmentation	Implant brand
8	den Hartog et al. 2013; den Hartog et al. 2017/ Netherlands	Three arms, parallel	92 (92)	Intervention-1: 7.2 [12.9]; Intervention-2: 40.1 [14.4]; Intervention-3: 40.1 [17.2]	46/47	Intervention-1: "smooth" implant neck Intervention-2: "rough" implant neck Intervention-3: "scalloped" implant neck	Deferred augmentation types within one study	Nobel Biocare, Nobel Biocare
9	den Hartog et al. 2016/ Netherlands	Two arms, parallel	62 (62)	Intervention-1: 40.1 [14.4] Intervention-2: 38.4 [14.0]	26/36	Intervention-1: conventional impl loading after 3 months Intervention-2: immediate impl loading with temporay crown withing 24h	Bone (if needed)	Nobel Replace Tapered Groove implant, Nobel Biocare
10	Esposito et al. 2018; Peñarocha-Oltra et al. 2019; Fernández et al. 2020/Spain	Two arms, parallel	30 (30)	Intervention-1: 47.5 (23–70) Intervention-2: 47 (20–65)	11/19	Intervention-1: impl positioned in the natural "centra" position Intervention-2: impl positioned about 3 mm more palatally	Bone (if needed)	Ticare Inhex implants, Mozo-Grau Ticare
11	Felice et al. 2015/ Italy	Two arms, parallel	50 (50)	Intervention-1: 53.0 (39–72) Intervention-2: 51.3 (32–71)	25/25	Intervention-1: ARP with algae-derived (phycogenic) bone substitute; Intervention-2: immediate impl placement	Intervention-1: ARP	XiVES plus, Dentsply Friadent
12	Felice et al. 2011; Esposito et al. 2015/Italy	Two arms, parallel	106 (106)	Intervention-1: 50 (30–72) Intervention-2: 48 (28–70)	46/60	Intervention-1: ARP with DBBM; Intervention-2: immediate implant placement	Intervention-1: ARP	MegaGen implant, Gyeongbuk
13	Gallucci et al. 2011/ Switzerland	Two arms, parallel	20 (20)	NR	NR	Intervention-1: porcelain-fused-to-ceramic single-impl crown; Intervention-2: all-ceramic single-impl crown	No	Standard plus, straumann
14	Garcia-Sanchez et al. 2021/Spain	Two arms, parallel	28 (28)	Intervention-1: 47 [10.2] Intervention-2: 47 [10.8]	10/18	Intervention-1: flap; Intervention-2: minimal split-thickness envelope flap	No	Biomimetic OCEAN, Avinent implants

(Continues)

TABLE 2 | (Continued)

N	Study/Country	RCT type	Participants			Implants		
			Number of patients (implants)	Age, years, mean [SD] (range)	Gender (male/female)	Type of intervention	Type of augmentation	Implant brand
15	Gjelvold et al. 2017/ Sweden	Two arms, parallel	50 (50)	Intervention-1: 40.9 [15.5] Intervention-2: 40.8 [13.3]	20/30	Intervention-1: delayed loading after 4 months; Intervention-2: immediate impl. loading with temporary crown	Bone (if needed)	Tapered Internal implants, Bio-Horizons
16	Hassani et al. 2021/Iran	Two arms, parallel	40 (40)	Intervention-1: 42.8 [3.4] Intervention-2: 38.1 [4.9]	16/24	Intervention-1: delayed loading after 3 months; Intervention-2: immediate impl. loading with temporary crown within 48 h	Bone	Supertine, dentium
17	Jonker et al. 2021/ Netherlands	Three arms, parallel	75 (75)	Intervention-1: 44 [12] Intervention-2-1: 50 [13] Intervention-3: 49 [16]	33/42	Intervention-1: spontaneous healing; Intervention-2: ARP with DBBM covered with a palatal graft; Intervention-3: ARP with DBBM covered by collagen matrix	Intervention-1: No augmentation; Intervention-2-1 ARP and soft tissue; Intervention-3: ARP	Bone level tapered, SLActive, Straumann
18	Jonker et al. 2018/ Netherlands	Two arms, parallel	52 (52)	Intervention-1: 49.0 [14.1]; Intervention-2: 45.0 [10.8]	30/22	Intervention-1: ridge augmentation without resorbable membrane; Intervention-2: ridge augmentation with resorbable membrane	Bone	Bone level, straumann
19	Meijndert et al. 2007/ Netherlands	Three arms, parallel	93 (93)	33.3 (18–63)	44/49	Intervention-1: GBR with autologous bone from chin; Intervention-2: GBR with autologous bone from chin & DBBM; Intervention-3: GBR with DBBM	Bone	Straumann
20	Ruiz Henao et al. 2021; Henao et al. 2024/Spain	Two arms, parallel	30 (30)	Intervention-1: 56.0 Intervention-2: 54.1	14/16	Intervention-1: titanium impl; Intervention-2: ceramic impl	Bone (if needed)	Intervention-1: tissue level SLA titanium implants, Straumann; Intervention-2: Straumann PURE Ceramic implants, Straumann

(Continues)

TABLE 2 | (Continued)

N	Study/Country	RCT type	Participants			Implants		
			Number of patients (implants)	Age, years, mean [SD] (range)	Gender (male/female)	Type of intervention	Type of augmentation	Implant brand
21	Santhanakrishnan et al. 2021; Santhanakrishnan et al. 2024/India	Three arms, parallel	75 (75)	Intervention-1: 30.8 [6.5]; Intervention-2-1: 30.6 [6.3] Intervention-3: 29.8 [9.7]	34/41	Intervention-1: delayed impl placement within 4 months; Intervention-2: socket shield; Intervention-3: immediate impl. placement	Intervention-2: bone	DIO implant system, Busan
22	Slagter et al. 2015; Slagter et al. 2021; Donker et al. 2024/Netherlands	Two arms, parallel	40 (40)	Intervention-1: 42.3 [14.2] Intervention-2: 39.5 [16.9]	13/27	Intervention-1: delayed impl loading after 3 months; Intervention-2: immediate impl loading with temporary crown	No	Nobel/Active TiUnité, Nobel Biocare
23	Slagter et al. 2016; Slagter et al. 2021; Meijer et al. 2024/Netherlands	Two arms, parallel	40 (40)	Intervention-1: 48.6 [16.4] Intervention-2: 43.7 [13.9]	18/22	Intervention-1 delayed impl placement after ARP; Intervention-2 immediate impl placement	Intervention-1s: ARP	Nobel/Active, Nobel Biocare
24	Vazouras et al. 2022/USA	Three arms, cross-over	25 (25)	43 (21–64)	8/17	Intervention-1: gray titanium abutment; Intervention-2 pink anodized titanium abutment; Intervention-3 hybrid zirconia customized abutment	No	Genesis, keystone dental
25	Wanis et al. 2022/Egypt	Two arms, parallel	24 (24)	Intervention-1: 30.3 [6.6] Intervention-2: 34.2 [7.9]	7/17	Intervention-1: immediate impl placement with GBR and immediate loading with temporary crown; Intervention-2: immediate impl placement with dual-zone therapeutic concept	Intervention-1: Bone	IS-II implant, Neobiotech
26	Witneben et al. 2023/Switzerland	Two arms, parallel	40 (40)	NR	NR	Intervention-1 individualized CAD/CAM abutment; Intervention-2 prefabricated stock abutment	No	Bone level implant; Straumann

(Continues)

TABLE 2 | (Continued)

N	Study/Country	RCT type	Participants			Implants		
			Number of patients (implants)	Age, years, mean [SD] (range)	Gender (male/female)	Type of intervention	Type of augmentation	Implant brand
27	Zamora et al. 2024 /Spain ^a	Three arms, parallel	45 (45)	Intervention-1: 45.5 [13.9]; Intervention-2: 48.1 [13.8] Intervention-3: 47.4 [16.2]	19/26	Intervention-1: metal-porcelain restoration; Intervention-2: lithium disilicate restoration; Intervention-3: porcelain-layered, zirconium restoration	Soft tissue	Biomimetic OCEAN, Avinent
28	Zuiderveld et al. 2018a/Netherlands	Three arms, parallel	60 (60)	Intervention-1: 42.0 [15.7] Intervention-2: 38.2 [16.7] Intervention-3: 45.4 [17.0]	25/35	Intervention-1: spontaneous healing; Intervention-2: soft tissue augmentation with CTG from palate; Intervention-3: soft tissue augmentation with XCM	Soft tissue	Nobel Replace CC, Nobel Biocare
29	Zuiderveld et al. 2018b; Zuiderveld et al. 2024/Netherlands	Two arms, parallel	60 (60)	Intervention-2: 47.8 [16.5] Intervention-2: 45.5 [15.5]	28/32	Intervention-1: spontaneous healing; Intervention-2: soft tissue augmentation with CTG from tuberosity	Intervention-2: soft tissue	NobelActive, Nobel Biocare

Abbreviations: ARP, alveolar ridge preservation; CMX, collagen matrix; CTG, connective tissue graft; DBBM, deproteinized bovine bone mineral; GBR, guided bone regeneration; imp, implant; NR, not reported.

^aData reported as a median.

Study	Risk of bias domains					
	D1	D2	D3	D4	D5	Overall
Atef et al., 2021	+	+	+	-	+	-
de Beus et al., 2024	+	+	+	+	+	+
Borgia et al., 2022	+	+	+	+	+	+
Canullo et al., 2016	+	-	+	+	+	-
Carrillo de Albornoz et al., 2014	+	+	+	+	+	+
Cosyn et al., 2021	+	+	+	+	+	+
Cosyn et al., 2022	+	+	+	+	+	+
De Bruyckere et al., 2020	+	+	+	+	+	+
den Hartog et al., 2013	+	+	+	+	+	+
den Hartog et al., 2016	+	+	+	+	+	+
den Hartog et al., 2017	+	+	+	+	+	+
Donker et al., 2024	+	+	-	+	+	-
Esposito et al., 2015	-	+	+	-	+	✗
Esposito et al., 2018	+	+	+	-	+	-
Felice et al., 2011	-	+	+	-	+	✗
Felice et al., 2015	-	+	+	-	+	✗
Fernández et al., 2020	+	+	+	-	+	-
Ferrantino et al., 2023	+	+	+	+	+	+
Gallucci et al., 2011	+	+	+	+	+	+
García-Sánchez et al., 2021	+	+	-	+	+	-
Gjelvold et al., 2017	+	+	+	+	+	+
Hassani et al., 2021	+	+	+	+	+	+
Henao et al., 2024	+	+	-	+	+	-
Jonker et al., 2018	+	+	+	+	+	+
Jonker et al., 2021	+	+	+	+	+	+
Meijndert et al., 2007	+	+	+	+	+	+
Meijer et al., 2024	+	+	-	+	+	-
Peñarrocha-Oltra et al., 2019	+	+	+	-	+	-
Ruiz Henao et al., 2021	+	+	+	+	+	+
Santhanakrishnan et al., 2021	+	+	+	-	+	-
Santhanakrishnan et al., 2024	+	+	+	-	+	-
Slagter et al., 2015	+	+	+	+	+	+
Slagter et al., 2016	+	+	+	+	+	+
Slagter et al., 2021	+	+	+	+	+	+
Surdiacourt et al., 2024	+	+	+	+	+	+
Vazouras et al., 2022	+	+	+	-	+	-
Wanis et al., 2022	+	+	+	+	+	+
Wittneben et al., 2024	+	+	+	+	+	+
Zamora et al., 2024	+	+	+	+	+	+
Zuiderveld et al., 2018a	+	+	+	+	+	+
Zuiderveld et al., 2018b	+	+	+	+	+	+
Zuiderveld et al., 2024	+	+	+	+	+	+

Domains:
D1: Bias arising from the randomization process.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D4: Bias in measurement of the outcome.
D5: Bias in selection of the reported result.

Judgement
✗ High
+ Some concerns
+ Low

FIGURE 2 | Risk of bias assessment for randomized controlled trials.

population (60 patients [4.2%]) was not reported. The included studies evaluated a variety of interventions. Among these, nine trials focused on implant loading protocols; four studies on abutment characteristics; four on bone augmentation; three on soft tissue augmentation; two on implant materials; and two on implant-supported restoration material. Additionally, one study each investigated implant placement protocol, flap design, alveolar ridge preservation, implant position, cleaning protocol, and neck characteristics. Various types of bone and soft tissue augmentation within different time points were performed within included studies according to the proposed study design.

3.3 | Patient-Reported Outcomes (PROs) Regarding Esthetics

The identified PROs regarding esthetics in the selected literature were assessed with the following measuring tools:

- PRO: Overall/general satisfaction/appearance/smile ($n = 22$)
 - Measuring instrument: Visual Analog Scale (VAS) (16/22); Unstandardized questionnaire (6/22).
- PRO: Pink/gum/mucosal esthetics ($n = 16$)
 - Measuring instrument: Unstandardized questionnaire (7/16); VAS (9/16).
- PRO: Colour of gum ($n = 7$)
 - Measuring instrument: Unstandardized questionnaire (4/7); VAS (3/7).
- PRO: Shape of gum ($n = 7$)
 - Measuring instrument: Unstandardized questionnaire (4/7); VAS (3/7).
- PRO: White/crown esthetics ($n = 12$)
 - Measuring instrument: Unstandardized questionnaire (4/12); VAS (8/12).
- PRO: Crown color ($n = 7$)
 - Measuring instrument: Unstandardized questionnaire (4/7); VAS (3/7).
- PRO: Crown shape ($n = 7$)
 - Measuring instrument: Unstandardized questionnaire (4/7); VAS (3/7).
- PRO: esthetic satisfaction/appearance ($n = 2$)
 - Measuring instrument: Visual Analog Scale (VAS) (2/9).
- PRO: Oral health-related quality-of-life ($n = 6$)
 - Measuring instrument: OHIP-14 (6/6).

Table 3 provides detailed qualitative information on the PROs and measuring instruments used in the selected studies. Moreover, one study evaluated the domain of overall satisfaction by several measuring tools.

3.4 | Clinician-Reported Outcome Measures (ClinROs) Regarding Esthetics

The identified objective ClinRO regarding esthetics in the selected literature was the following:

TABLE 3 | Characteristics of the included studies–Patient-reported outcome measures and clinician-reported outcome measures.

Characteristics									
Patient-reported outcome measures					Clinician reported outcome measures				
PROMs scale (range, min/max)		Evaluated question, regarding esthetics (key aspects)		Results, mean [SD] (range)	Results, mean [SD] (range)		Method of evaluation	Results	
N	Study/Country							Evaluated timepoint	
1	Atef et al. 2021 / Egypt	VAS (0/10 cm)	White esthetics Pink esthetics	Intervention-1: 9.3 [0.9] Intervention-2: 9.2 [0.7] Intervention-1: 9.3 [0.1] Intervention-2: 9.2 [0.7]	Midfacial recession: Intervention-1: 0.4 [0.7] mm Intervention-2: -0.4 [0.5] mm PES: Intervention-1: 12.1 [0.6] Intervention-2: 11.8 [0.3]	IOS and digital superimposition (Exocad, CAD software, Germany) Intra-oral photographs	1Y FU		
2	de Beus et al. 2024 / Netherlands	Questionnaire Guljé et al. (0%–100%)	Crown color Crown shape Gum color Gum shape Overall satisfaction	NR NR NR NR Intervention-1: 96.0 [5.3] Intervention-2: 93.1 [4.3]	PES: Intervention-1: 6.5 [1.6] Intervention-2: 11.8 [0.3] PES/WES: Intervention-1: 12.7 [4.2] Intervention-2: 13.1 [3.0] WES: Intervention-1: 6.2 [3.2] Intervention-2: 6.6 [2.2]	Intra-oral photographs Intra-oral photographs Intra-oral photographs	1Y FU		
3	Borgia et al. 2022 / Uruguay	VAS (0/10 cm) OHIP-14 (0/56)	Overall satisfaction Health-related quality	Unclear reported data	PES: Intervention-1: 10.8 [1.9] Intervention-2: 11.5 [1.7]	NR	1Y FU		
4	Canullo et al. 2016 /Spain	VAS (0/10 cm)	Overall satisfaction	Intervention-1: 9.5 [2.8] Intervention-2: 9.6 [4.1]	Buccal peri-implant mucosa changes at the zenith: Intervention-1: 0.2 [0.3] Intervention-2: 0.5 [0.6]	Customized prefabricated stent	5Y FU		
5	Carrillo de Albornoz et al. 2014 ; Ferrantino et al. 2023 /Spain	Unstandardized question (1/6) VAS (0/10 cm)	Overall satisfaction Esthetics satisfaction	Unclear reported data Intervention-1: 8.5 [1.6] Intervention-2: 8.5 [1.7] Intervention-1: 9.0 [1.4] Intervention-2: 9.0 [1.7] Unclear reported data Intervention-1: 9.0 [1.8] Intervention-2: 8.8 [1.1]	ICAI-crown: Intervention-1: 3.4 [3.4] Intervention-2: 2.0 [2.0] ICAI-mucosa: Intervention-1: 7.2 [2.7] Intervention-2: 5.7 [3.0] ICAI-total: Intervention-1: 10.6 [4.4] Intervention-2: 7.8 [3.2] ICAI-crown: Intervention-1: 4.4 [4.7] Intervention-2: 2.2 [1.9] ICAI-mucosa: Intervention-1: 6.8 [3.1] Intervention-2: 5.3 [3.0] ICAI-total: Intervention-1: 11.2 [5.4] Intervention-2: 7.6 [3.5] ICAI-crown: Intervention-1: 5.6 [4.3] Intervention-2: 4.1 [3.4] ICAI-mucosa: Intervention-1: 5.9 [2.2] Intervention-2: 3.6 [1.3] ICAI-total: Intervention-1: 11.5 [5.6] Intervention-2: 7.8 [3.5]	Intra-oral photographs Intra-oral photographs Intra-oral photographs	1M FU 1Y FU 5Y FU		

(Continues)

TABLE 3 | (Continued)

Characteristics					Clinician reported outcome measures			Results
Patient-reported outcome measures			Results, mean [SD] (range)			Method of evaluation	Evaluated timepoint	
N	Study/Country	PROMs scale (range, min/max)	Evaluated question, regarding esthetics (key aspects)	Results, mean [SD] (range)				
6	Cosyn et al., 2021; Cosyn et al. 2022; Surdiacourt et al. 2024/ Belgium	VAS (0/100mm)	Gums esthetics	Intervention-1: 80.7 (71.8–89.5) Intervention-2: 82.0 (73.3–90.7) Intervention-1: 89.6 (82.3–96.9) Intervention-2: 89.3 (82.0–96.6) Intervention-1: 89.6 (82.8–96.3) Intervention-2: 91.8 (85.0–98.5)	Midfacial recession: Intervention-1: 0.1 mm (–0.4 to 0.7); Intervention-2: 0.9 mm (0.3–1.5) Mucosal scarring index: Intervention-1: 2.0 (1.6–2.4); Intervention-2: 1.7 (1.3–2.1) PES: Intervention-1: 10.4 (9.7–11.2) Intervention-2: 10.5 (9.8–11.3) Midfacial recession: Intervention-1: 0.3 (0.2–0.5); Intervention-2: 0.3 (0.2–0.5) Mucosal Scarring Index: Intervention-1: 1.3 (0.4–2.2); Intervention-2: 1.3 (0.4–2.3) PES: Intervention-1: 11.9 (10.8–13.1); Intervention-2: 11.2 (10.1–12.3) Midfacial recession: Intervention-1: 0.2 (0.0–0.5); Intervention-2: 0.1 (0.0–0.4) Mucosal Scarring Index: Intervention-1: 2.1 (1.4–2.7); Intervention-2: 1.7 (1.0–2.4) PES: Intervention-1: 10.9 (10.2–11.5); Intervention-2: 10.5 (9.8–11.2)	IOS and digital superimposition (SMOP, Swissmeda, Switzerland) Intra-oral photographs Intra-oral photographs	3M FU 1Y FU 3Y FU	
7	De Bruyckere et al. 2020/ Belgium	VAS (0/100mm) OHIP-14 (0/56)	Soft tissue Crown Health-related quality	Intervention-1: 84 [14] Intervention-2: 87 [15] Intervention-1: 88 [10] Intervention-2: 92 [5] Intervention-1: 18.6 [5.5] Intervention-2: 15.7 [2.3]	Mucosal scarring index: Intervention-1: 2.5 [2.1]; Intervention-2: 1.1 [1.3] PES: Intervention-1: 10.1 [1.8]; Intervention-2: 10.4 [2.2] WES: Intervention-1: 8.7 [1.5]; Intervention-2: 8.4 [1.1]	Intra-oral photographs Intra-oral photographs Intra-oral photographs	1Y FU	
8	den Hartog et al. 2013; den Hartog et al. 2017/ Netherlands	Unstandardized questions (1/5) VAS (0/10 cm)	Color of the crown Shape of the crown Color of the gums Shape of the gums General satisfaction	Intervention-1: 28 pat.=5; Intervention-2: 30 pat.=5; Intervention-3: 28 pat.=5; Intervention-1: 28 pat.=5; Intervention-2: 31 pat.=5; Intervention-3: 29 pat.=5; Intervention-1: 26 pat.=5; Intervention-2: 27 pat.=5; Intervention-3: 26 pat.=5; Intervention-1: 24 pat.=5; Intervention-2: 27 pat.=5; Intervention-3: 24 pat.=5; Intervention-1: 8.8 [1.1]; Intervention-2: 8.9 [1.0]; Intervention-3: 9.1 [0.8] Intervention-1: 8.4 [0.9]; Intervention-2: 9.1 [0.9]; Intervention-3: 8.6 [1.5]	ICAI crown: Intervention-1: Excellent: 1 pat; Satisfactory: 17 pat; Moderate: 10 pat; Poor: 2 pat; Intervention-2: Excellent: 1 pat; Satisfactory: 18 pat; Moderate: 10 pat; Poor: 2 pat; Intervention-3: Excellent: 1 pat; Satisfactory: 19 pat; Moderate: 7 pat; Poor: 4 pat ICAI mucosa: Intervention-1: Excellent: 2 pat; Satisfactory: 14 pat; Moderate: 8 pat; Poor: 6 pat; Intervention-2: Satisfactory: 15 pat; Moderate: 6 pat; Poor: 10 pat; Intervention-3: Satisfactory: 21 pat; Moderate: 4 pat; Poor: 6 pat; PES: Intervention-1: 6.0 [1.9]; Intervention-2: 6.3 [1.7]; Intervention-3: 6.6 [1.6]; WES: Intervention-1: 7.2 [1.5]; Intervention-2: 7.4 [1.6]; Intervention-3: 7.2 [1.6]; PES: Intervention-1: 6.5 [1.3]; Intervention-2: 6.8 [1.3]; Intervention-3: 6.4 [1.5]; WES: Intervention-1: 7.1 [1.4]; Intervention-2: 7.7 [1.2]; Intervention-3: 7.1 [1.4]	Intra-oral photographs Intra-oral photographs Intra-oral photographs Intra-oral photographs	1Y FU 5Y FU	

(Continues)

TABLE 3 | (Continued)

Characteristics							
Patient-reported outcome measures				Clinician reported outcome measures			
N	Study/Country	PROMs scale (range, min/max)	Evaluated question, regarding esthetics (key aspects)	Results, mean [SD] (range)	Method of evaluation	Results	
				Results, mean [SD] (range)		Evaluated timepoint	
9	den Hartog et al. 2016/ Netherlands	Unstandardized question (1/5) VAS (0/100mm)	Color of the crown Form of the crown Color of the mucosa around the crown Form of the mucosa around the crown Overall satisfaction	Intervention-1: 100 Intervention-2: 100 Intervention-1: 96.7 Intervention-2: 93.3 Intervention-1: 90.3 Intervention-2: 96.7 Intervention-1: 86.6 Intervention-2: 80.6 Intervention-1: 89.5 [9.5] Intervention-2: 91.5 [8.4] Intervention-1: 96.8 Intervention-2: 93.3 Intervention-1: 100 Intervention-2: 100 Intervention-1: 87.0 Intervention-2: 96.6 Intervention-1: 87.0 Intervention-2: 86.6 Intervention-1: 89.0 [9.8] Intervention-2: 92.7 [9.0] Intervention-1: 96.4 Intervention-2: 92.6 Intervention-1: 89.3 Intervention-2: 96.3 Intervention-1: 92.9 Intervention-2: 96.3 Intervention-1: 82.1 Intervention-2: 88.9 Intervention-1: 91.3 [9.4] Intervention-2: 93.5 [7.1] Intervention-1: 9 pat = 5; 1 pat = 4; Intervention-2: 4 pat- 5, 3 pat- 4 Intervention-1: 10 pat = 5; Intervention-2: 9 pat-5, 1 pat- 4 Intervention-1: 10 pat = 5; Intervention-2: 9 pat-5, 1 pat- 4	Papilla index: Intervention-1: 0–3.2; 1–27.5; 2–46.8; 4–22.6 Intervention-2: 0–1.7; 1–28.3; 2–51.7; 4–18.3 Papilla index: Intervention-1: 0–1.6; 1–19.4; 2–45.2; 4–33.9 Intervention-2: 1–21.7; 2–35.0; 4–43.3 PES: Intervention-1: 6.5 [1.6]; Intervention-2: 7.1 [1.5]; WES: Intervention-1: 7.6 [1.6]; Intervention-2: 7.8 [1.5]; Papilla index: Intervention-1: 1–22.2; 2–51.9; 4–25.9; Intervention-2: 1–15.4; 2–48.0; 4–36.5 PES: Intervention-1: 6.8 [1.3]; Intervention-2: 7.2 [1.5]; WES: Intervention-1: 7.7 [1.2]; Intervention-2: 7.9 [1.2]	Clinically Intra-oral photographs Intra-oral photographs	CI 1Y FU 5Y FU
10	Esposito et al. 2018; Peñarocha-Oltra et al. 2019; Fernández et al. 2020/Spain	Unstandardized question (1/5)	Gum esthetics	Intervention-1: 9 pat = 5; Intervention-2: 1 pat = 4; Intervention-2: 4 pat- 5, 3 pat- 4 Intervention-1: 10 pat = 5; Intervention-2: 9 pat-5, 1 pat- 4 Intervention-1: 10 pat = 5; Intervention-2: 9 pat-5, 1 pat- 4	PES: Intervention-1: 10.0 [4.5] Intervention-2: 6.0 [9.0] PES: Intervention-1: 12.5 [5.0] Intervention-2: 10.0 [10.0] PES: Intervention-1: 10.0 [5.5] Intervention-2: 8.5 [6.7]	Intra-oral photographs	1Y FU 3Y FU 5Y FU
11	Felice et al. 2015/ Italy	Unstandardized question (1/5)	Gum esthetics	Intervention-1: 25 pat = 5 Intervention-2: 25 pat-5	PES: Intervention-1: 12.2 [1.1] Intervention-2: 12.7 [1.0]	Intra-oral photographs	1Y FU

(Continues)

(Continues)

TABLE 3 | (Continued)

N	Study/Country	Characteristics					Results
		Patient-reported outcome measures		Clinician reported outcome measures			
		PROMs scale (range, min/max)	Evaluated question, regarding estheticse (key aspects)	Results, mean [SD] (range)	Results, mean [SD] (range)	Method of evaluation	
12	Felice et al. 2011; Esposito et al. 2015/Italy	Unstandardized question (1/5)	Gum esthetics	Intervention-1: 52 pat = 5 Intervention-2: 52 pat-5 99 pat = 5; 2 pat = 4	PES: Intervention-1: 12.6 [1.0] Intervention-2: 12.7 [1.2] PES: Intervention-1: 13.0 [1.5] Intervention-2: 12.8 [1.4]	Intra-oral photographs	4M FY 1Y FU
13	Gallucci et al. 2011/Switzerland	VAS (0/10 cm)	Esthetics satisfaction	Intervention-1: 91.8 [5.9]; Intervention-2: 91.7 [10.0]	PES/WES: Intervention-1: 13.8 [2.1]; Intervention-2: 13.1 [2.6]	Intra-oral photographs	2Y FU
14	Garcia-Sanchez et al. 2021/S	Questionnaire Bruyn et al., (1–100%) VAS (0/100 cm)	Overall satisfaction Overall satisfaction	Intervention-1: 69.2%; Intervention-2: 84.6% NR	PES: Intervention-1: 10.5 [2.4]; Intervention-2: 10.5 [2.4]; WES: Intervention-1: 6.9 [1.9]; Intervention-2: 6.9 [2.4]	Intra-oral photographs Intra-oral photographs	1Y FU
15	Gjelvold et al. 2017/Swe	OHIP-14 (0/56) VAS (0/100 mm)	Health-related quality Overall satisfaction	OHIP-14: Intervention-1 18.6 [9.0]; Intervention-2: 18.6 [5.3] OHIP-14: Intervention-1 16.4 [7.0]; Intervention-2: 16.9 [4.6] OHIP-14: Intervention-1 15.3 [2.5]; Intervention-2: 16.4 [3.8] VAS: Intervention-1: 87.9 [11.3]; Intervention-2: 89.6 [9.5]	Gingival zenith: Intervention-1: –0.3 [–0.5]; Intervention-2: –0.1 [0.5]; PES: Intervention-1: 9.4 [2.9]; Intervention-2: 8.5 [2.2]; WES: Intervention-1: 7.0 [1.6]; Intervention-2: 7.0 [1.4]; PES: Intervention-1: 10.3 [2.6]; Intervention-2: 9.7 [2.3]; WES: Intervention-1: 7.5 [1.6]; Intervention-2: 7.5 [1.3]; PES: Intervention-1: 10.6 [2.3]; Intervention-2: 10.3 [2.4]; WES: Intervention-1: 7.8 [1.3]; Intervention-2: 7.7 [1.3]	Superimposed photographs of study casts (ImageJ software, USA) Intra-oral photographs Intra-oral photographs	CI 6M FU 1Y FU
16	Hassani et al. 2021/Iran	Unstandardized question (0/4)	Overall esthetic	Intervention-1: 16 pat = 4, yes, absolutely, 2 pat = 3, yes, partly, 1pat = 2, not sure, 1 pat = 1, not really Intervention-2: 18 pat = 4, yes, absolutely, 1 pat = 3, yes, partly, 1pat = 2, not sure	PES: Intervention-1: 10.2 [0.9] Intervention-2: 11.2 [1.1] WES: Intervention-1: 7.6 [1.2] Intervention-2: 8.0 [1.0]	Intra-oral photographs Intra-oral photographs	1Y-FU

(Continues)

TABLE 3 | (Continued)

Characteristics							
Patient-reported outcome measures				Clinician reported outcome measures			
N	Study/Country	PROMs scale (range, min/ max)	Evaluated question, regarding aesthetic (key aspects)	Results, mean [SD] (range)	Results, mean [SD] (range)	Method of evaluation	
						Evaluated timepoint	
17	Jonker et al. 2021/ Netherlands	VAS (0/10 cm)	Overall satisfaction Crown satisfaction Soft tissue satisfaction	Intervention-1: 8.3 [1.3] Intervention-2: 8.1 [2.3] Intervention-3: 8.1 [1.1] Intervention-1: 9.1 [1.2] Intervention-2: 8.6 [2.4] Intervention-3: 9.1 [0.9] Intervention-1: 8.5 [1.8] Intervention-2: 8.1 [2.4] Intervention-3: 8.1 [2.1] Intervention-1: 8.4 [1.0] Intervention-2: 8.4 [1.9] Intervention-3: 7.8 [1.3] Intervention-1: 9.0 [1.4] Intervention-2: 8.9 [1.6] Intervention-3: 9.0 [0.9] Intervention-1: 8.3 [2.1] Intervention-2: 8.4 [1.5] Intervention-3: 8.1 [2.0] Intervention-1: 7.9 [1.4] Intervention-2: 8.0 [2.1] Intervention-3: 7.9 [1.4] Intervention-1: 9.1 [1.0] Intervention-2: 8.8 [1.1] Intervention-3: 9.0 [1.2] Intervention-1: 8.3 [1.5] Intervention-2: 8.1 [1.7] Intervention-3: 8.0 [1.8]	PES: Intervention-1: 6.1 [1.4] Intervention-2: 6.2 [1.6] Intervention-3: 6.3 [1.1] WES: Intervention-1: 7.6 [1.4] Intervention-2: 7.7 [1.6] Intervention-3: 7.2 [1.5] PES: Intervention-1: 7.0 [1.4] Intervention-2: 6.8 [1.3] Intervention-3: 6.8 [1.3] WES: Intervention-1: 7.8 [1.0] Intervention-2: 7.6 [1.5] Intervention-3: 7.3 [1.4] PES: Intervention-1: 7.3 [1.7] Intervention-2: 7.1 [1.5] Intervention-3: 7.0 [1.4] WES: Intervention-1: 8.0 [0.9] Intervention-2: 7.8 [1.3] Intervention-3: 7.3 [1.7]	Intra-oral photographs Intra-oral photographs	BL 6M FU 1Y FU

(Continues)

TABLE 3 | (Continued)

Characteristics					Clinician reported outcome measures			Results	
		Patient-reported outcome measures							
N	Study/Country	PROMs scale (range, min/max)	Evaluated question, regarding esthetics (key aspects)	Results, mean [SD] (range)	Results, mean [SD] (range)	Method of evaluation	Evaluated timepoint		
18	Jonker et al. 2018/ Netherlands	VAS (0/10 cm)	Overall satisfaction Crown esthetics Mucosa esthetics	Intervention-1: 8.5 (7.7–9.4) Intervention-2: 8.5 (8.0–9.2) Intervention-1: 9.7 (8.5–10.0) Intervention-2: 9.1 (8.7–9.8) Intervention-1: 8.5 (6.9–9.0) Intervention-2: 8.1 (6.8–9.3) Intervention-1: 9.0 (8.1–9.7) Intervention-2: 8.8 (8.5–9.5) Intervention-1: 9.2 (8.0–9.8) Intervention-2: 9.6 (8.7–9.9) Intervention-1: 9.0 (7.6–9.6) Intervention-2: 7.9 (7.3–9.4) Intervention-1: 8.4 (7.8–9.7) Intervention-2: 8.3 (7.5–9.4) Intervention-1: 9.6 (8.5–9.9) Intervention-2: 9.1 (8.6–9.9) Intervention-1: 9.2 (6.6–9.9) Intervention-2: 8.5 (7.9–9.5)	PES: Intervention-1: 7.0 (5.5–7.8) Intervention-2: 6.3 (5.5–7.9) WES: Intervention-1: 9.0 (8.1–9.5) Intervention-2: 9.0 (8.1–9.5) PES: Intervention-1: 7.5 (7.0–9.0) Intervention-2: 8.0 (6.5–8.6) WES: Intervention-1: 9.0 (8.5–10.0) Intervention-2: 9.0 (8.5–9.5) PES: Intervention-1: 8.0 (6.5–9.5) Intervention-2: 7.8 (7.0–9.0) WES: Intervention-1: 9.5 (8.0–9.5) Intervention-2: 9.5 (8.5–9.6)	Intra-oral photographs	1M FU 6M FU 1Y FU		
19	Meijndert et al. 2007/ Netherlands	VAS (0/10 cm)	Overall satisfaction	8.5 (6–10)	ICAI-crown: 1.3 (0–9) ICAI-mucosa: 3.4 (0–11) ICAI-total: 4.8 (0–17)	Intra-oral photographs Intra-oral photographs Intra-oral photographs	1Y FU		
20	Ruiz Henao et al. 2021; Henao et al. 2024/Spain	Questionnaire Bruyn et al., NRS (0/10)	Esthetic appearance General satisfaction	Intervention-1: 9.5 (6–10.0) Intervention-2: 10.0 (8–10.0) Intervention-1: 10.0 (9–10.0) Intervention-2: 10.0 (9–10.0) Intervention-1: 9.0 (8.4–9.6) Intervention-2: 9.3 (8.8–9.9) Intervention-1: 9.4 (9.0–9.8) Intervention-2: 9.6 (9.2–10.0)	Esthetic rated by clinician by NRS: Intervention-1: 8.5 Intervention-2: 9.0; ICAI-crown: Intervention-1: 3.6; Intervention-2: 3.9 ICAI-mucosa: Intervention-1: 2.3; Intervention-2: 2.3 ICAI-total: Intervention-1: 6.0; Intervention-2: 6.3 PES: Intervention-1: 7.8 [1.2] Intervention-2: 7.8 [1.7] Esthetic rated by clinician by NRS: Intervention-1: 7.5 Intervention-2: 8.1 ICAI-crown: Intervention-1: 2.5; Intervention-2: 2.8 ICAI-mucosa: Intervention-1: 1.9; Intervention-2: 2.5 ICAI-total: Intervention-1: 4.5; Intervention-2: 5.2 PES: Intervention-1: 7.4 Intervention-2: 7.4	Paper-based 1- item scale Intra-oral photographs Intra-oral photographs Intra-oral photographs	1Y FU 5Y FU		
21	Santhanakrishnan et al. 2021; Santhanakrishnan et al. 2024/India	VAS (0/10 cm)	Overall satisfaction	Intervention-1: 9.0 [0.6] Intervention-2: 8.7 [0.6] Intervention-3: 8.4 [0.8] Intervention-1: 9.2 [0.6] Intervention-2: 8.4 [1.0] Intervention-3: 8.0 [1.1]	PES: Intervention-1: 10.2 [1.4] Intervention-2: 11.7 [1.8] Intervention-3: 11.2 [2.1] PES: Intervention-1: 12.5 [1.0] Intervention-2: 10.1 [1.3] Intervention-3: 9.1 [1.0]	NR	6M FU 1Y FU		

(Continues)

TABLE 3 | (Continued)

Characteristics					Clinician reported outcome measures			Results
Patient-reported outcome measures			Clinician reported outcome measures			Results		
	PROMs scale (range, min/max)	Evaluated question, regarding esthetic (key aspects)	Results, mean [SD] (range)	Results, mean [SD] (range)	Method of evaluation	Evaluated timepoint		
22	Slagter et al. 2015; Slagter et al. 2021; Donker et al. 2024/ Netherlands	VAS (0/10 cm) Overall satisfaction	Intervention-1: 7.9 [1.8] Intervention-2: 8.1 [1.7] Intervention-1: 8.4 [1.1] Intervention-2: 8.7 [1.8] Intervention-1: 8.6 [1.8] Intervention-2: 8.4 [1.4]	Papilla Index Mesial: Intervention-1: 2.1 [0.8]; Intervention-2: 2.3 [0.6]; Distal: Intervention-1: 2.3 [0.7]; Intervention-2: 2.0 [0.6]; mPES: Intervention-1: 7.8 [1.6]; Intervention-2: 7.4 [1.5] PES/WES: Intervention-1: 16.2 [2.2] Intervention-2: 15.1 [1.7] WES: Intervention-1: 7.9 [1.7]; Intervention-2: 7.6 [1.0] Papilla Index Mesial: Intervention-1: 2.5 [0.7]; Intervention-2: 2.6 [0.7]; Distal: Intervention-1: 2.5 [0.7]; Intervention-2: 2.4 [0.6] mPES: Intervention-1: 7.8 [1.6]; Intervention-2: 7.0 [1.7] PES/WES: Intervention-1: 15.4 [2.6] Intervention-2: 15.7 [2.1] WES: Intervention-1: 7.5 [2.1]; Intervention-2: 8.2 [1.5] Papilla Index Mesial: Intervention-1: 2.5 [0.7]; Intervention-2: 2.6 [0.7]; Distal: Intervention-1: 2.5 [0.7]; Intervention-2: 2.4 [0.6] mPES: Intervention-1: 7.8 [1.6]; Intervention-2: 7.0 [1.7] PES/WES: Intervention-1: 15.4 [2.6]; Intervention-2: 15.7 [2.1] WES: Intervention-1: 7.5 [2.1]; Intervention-2: 8.2 [1.5]	Clinically Intra-oral photographs Intra-oral photographs Intra-oral photographs	1M FU 5Y FU 10Y FU		
23	Slagter et al. 2016; Slagter et al. 2021; Meijer et al. 2024/ Netherlands	VAS (0/100 mm) OHIP-14 (0/4) 5. Self-consciousness of teeth 13. General satisfaction Overall satisfaction	Intervention-1: 80.7 [12.3]; Intervention-2: 80.7 [12.3]; Intervention-1: 82.4 (14.3) Intervention-2: 77.7 (17.2) Intervention-1: 15 pat = 2, 3 pat = 3, 1 pat = 4; Intervention-2: 13 pat = 2, 4 pat = 3, 3 pat = 4; Intervention-1: 13 pat = 2, 3 pat = 3; 1 pat = 4; 1 pat = 5; Intervention-2: 17 pat = 2, 2 pat = 3; 1 pat = 4; Intervention-1: 82.4 [14.3]; Intervention-2: 77.7 [17.2] Intervention-1: 88.5 (83.9–93.2); Intervention-2: 80.7 (74.9–86.0)	Papilla Index Mesial: Intervention-1: 1.8 [1.0]; Intervention-2: 2.1 [0.9]; Distal: Intervention-1: 1.8 [1.0]; Intervention-2: 2.0 [0.9] PES Intervention-1: 7.4 [1.5]; Intervention-2: 7.8 [1.6]; WES Intervention-1: 7.6 [1.0]; Intervention-2: 7.9 [1.7]; Papilla Index: Intervention-1: Mesial: 6 pat = 1; 5 pat = 2; 9 pat = 3; Distal: 7 pat = 1; 7 pat = 2; 6 pat = 3; Intervention-2: Mesial: 3 pat = 1; 8 pat = 2; 9 pat = 3; Distal: 3 pat = 1; 8 pat = 2; 9 pat = 3; PES: Intervention-1: 7.4 [1.5] Intervention-2: 7.5 [1.6] WES: Intervention-1: 7.9 [1.1] Intervention-2: 8.1 [0.9] Papilla Index Mesial: Intervention-1: 2.4 [0.7]; Intervention-2: 2.2 [0.8]; Distal: Intervention-1: 2.3 [0.7]; Intervention-2: 2.2 [0.8]; PES: Intervention-1: 7.5 [1.3]; Intervention-2: 7.4 [1.8]; WES: Intervention-1: 7.0 [1.3]; Intervention-2: 7.3 [1.1]; Papilla Index Mesial: Intervention-1: 2.0; Intervention-2: 3.0; Distal: Intervention-1: 2.0; Intervention-2: 2.0; PES: Intervention-1: 6.9; Intervention-2: 7.4; PES/WES: Intervention-1: 14.0; Intervention-2: 15.0; WES: Intervention-1: 7.1; Intervention-2: 7.6	Clinically Intra-oral photographs Intra-oral photographs	1M FU 1Y FU 5Y FU 10Y FU		

(Continues)

TABLE 3 | (Continued)

N	Study/Country	Characteristics					Results
		Patient-reported outcome measures		Clinician reported outcome measures			
		PROMs scale (range, min/max)	Evaluated question, regarding esthetic (key aspects)	Results, mean [SD] (range)	Results, mean [SD] (range)	Method of evaluation	
24	Vazouras et al. 2022/USA	VAS (0/10cm)	Color of tooth Color of gum Shape of gum Overall smile	Intervention-1: 7.1 [1.6] Intervention-2: 8.1 [1.4]; Intervention-3: 8.7 [0.9] Intervention-1: 7.0 [1.7] Intervention-2: 8.1 [1.3]; Intervention-3: 8.8 [1.0] Intervention-1: 7.8 [1.4] Intervention-2: 8.4 [1.4]; Intervention-3: 8.2 [1.3] Intervention-1: 7.6 [1.7] Intervention-2: 8.5 [1.3]; Intervention-3: 8.6 [1.2] Intervention-2: 9.0 [1.4] Intervention-3: 9.1 [1.0] Intervention-2: 9.3 [1.0] Intervention-3: 9.1 [1.1] Intervention-2: 8.8 [1.5] Intervention-3: 9.1 [0.9] Intervention-2: 9.0 [1.4] Intervention-3: 9.2 [0.9]	PES: Intervention-1: 9.6 [1.4] Intervention-2: 10.1 [1.1] Intervention-3: 10.8 [0.8] PES: Intervention-1: NR Intervention-2: 11.2 [1.2] Intervention-3: 12.0 [0.7]	NR	BL 1Y FU
25	Wanis et al. 2022/Egypt	Unstandardized questions (1/10)	Implant compared to natural tooth Color of implant crown compared to natural tooth Gingival contour compared to natural tooth Gingival color compared to natural tooth General satisfaction	Intervention-1: 7.5 [0.5]; Intervention-2: 7.8 [0.7]; Intervention-1: 7.2 [0.7]; Intervention-2: 7.3 [0.5]; Intervention-1: 8.3 [0.6]; Intervention-2: 8.3 [0.6]; Intervention-1: 10.0 [0.0]; Intervention-2: 10.0 [0.0]; Intervention-1: 9.0 [0.6]; Intervention-2: 9.1 [0.6]	Mid-facial recession: Intervention-1 0.4 [0.4]; Intervention-2 0.2 [0.3] PES: Intervention-1 10.8 [1.5]; Intervention-2 11.3 [1.6]	Clinically NR	1Y FU

(Continues)

TABLE 3 | (Continued)

Characteristics					Clinician reported outcome measures			Results	
Patient-reported outcome measures			Clinician reported outcome measures			Results, mean [SD] (range)		Method of evaluation	Evaluated timepoint
N	Study/Country	PROMs scale (range, min/ max)	Evaluated question, regarding esthetic (key aspects)	Results, mean [SD] (range)	Results, mean [SD] (range)	Results, mean [SD] (range)	Results, mean [SD] (range)	Method of evaluation	Evaluated timepoint
26	Wittneben et al., 2023/Switzerland	VAS (0/100mm)	Overall satisfaction Crown Esthetics Mucosa Esthetics	Intervention-1: 93.1 [8.7]; Intervention-2: 91.1 [8.7]; Intervention-1: 89.9 [13.6]; Intervention-2: 94.0 [6.4]; Intervention-1: 89.6 [12.8]; Intervention-2: 87.9 [12.3]; Intervention-1: 93.4 [15.6]; Intervention-2: 97.2 [4.9]; Intervention-1: 88.7 [21.1]; Intervention-2: 92.8 [12.0]; Intervention-1: 94.4 [12.8]; Intervention-2: 90.7 [9.4]	ICAI: values NR mPES: values NR PES/WES: values NR WES: values NR	ICAI: values NR mPES: values NR PES/WES: values NR WES: values NR	NR	1 week after crown insertion 5Y FU	
27	Zamora et al. 2024/Spain ^a	VAS (0/10 cm)	Esthetics satisfaction	Intervention-1: 9.0; Intervention-2: 10.0; Intervention-3: 8.0 Intervention-1: 9.0; Intervention-2: 10.0; Intervention-3: 8.0	PES: Intervention-1: 6.0; Intervention-2: 7.0; Intervention-3: 8.0; WES: Intervention-1: 6.0; Intervention-2: 8.0; Intervention-3: 7.0; PES: Intervention-1: 7.0; Intervention-2: 8.0; Intervention-3: 8.0; WES: Intervention-1: 6.0; Intervention-2: 8.0; Intervention-3: 7.0		Intra-oral photographs Intra-oral photographs	Crown insertion 1Y FU	
28	Zuiderveld et al. 2018a/ Netherlands	OHIP-14 (answered on a VAS scale) (0/10 cm) VAS (0/10 cm)	Implant and implant crown Color of crown Form of crown Color of peri- implant mucosa Form of peri- implant mucosa Overall satisfaction	Intervention-1: 8.7 (8.3–9.5) Intervention-2: 8.4 (6.9–9.2) Intervention-3: 9.3 (8.8–10.0) Intervention-1: 9.3 (7.2–9.9) Intervention-2: 8.8 (6.8–9.9) Intervention-3: 9.6 (8.9–10.0) Intervention-1: 9.0 (7.7–9.7) Intervention-2: 9.3 (7.1–9.9) Intervention-3: 9.8 (9.2–10.0) Intervention-1: 8.0 (6.9–9.7) Intervention-2: 8.6 (7.2–9.6) Intervention-3: 9.5 (8.6–10.0) Intervention-1: 7.6 (5.3–9.5) Intervention-2: 8.3 (5.6–9.7) Intervention-3: 9.0 (7.0–10.0) Intervention-1: 8.2 (7.4–8.8) Intervention-2: 7.9 (6.8–9.0) Intervention-3: 8.8 (7.6–9.6)	Mid-buccal mucosa level Intervention-1: –0.4 [1.5] Intervention-2: 0.0 [1.1]; Intervention-3: –0.1 [1.3] Papilla Index: Intervention-1: Mesial: 9 pat = 3; Distal: 11 pat = 2; 9 pat = 3; Intervention-2: Mesial: 3 pat = 2; 17 pat = 3; Distal: 5 pat = 2; 15 pat = 3; Intervention-3: Mesial: 2 pat = 1; 7 pat = 2; 11 pat = 3; Distal: 2 pat = 1; 10 pat = 2; 8 pat = 3; PES: Intervention-1: 6.6 [1.5] Intervention-2: 7.0 [2.4] Intervention-2: 6.1 [1.7] WES: Intervention-1: 8.7 [0.9] Control 2: 8.9 [1.2] Intervention-2: 8.3 [1.6]		Intra-oral photographs calibrated by a periodontal probe Clinically Intra-oral photographs Intra-oral photographs	1Y FU	

(Continues)

TABLE 3 | (Continued)

N	Study/Country	Characteristics					Evaluated timepoint
		Patient-reported outcome measures		Clinician reported outcome measures			
		PROMs scale (range, min/ max)	Evaluated question, regarding esthetic (key aspects)	Results, mean [SD] (range)	Results, mean [SD] (range)	Method of evaluation	
29	Zuiderveld et al. 2018b ; Zuiderveld et al. 2024 / Netherlands	OHIP-14 (0/56) VAS (0/10cm)	Color of the crown Form of the crown Color of the mucosa around the crown Form of the mucosa around the crown Overall satisfaction Overall satisfaction	OHIP: Intervention-1 10.0; Intervention-2: 10.0 VAS: Intervention-1 9.5; Intervention-2: 9.3; Intervention-1 9.3; Intervention-2: 9.2; Intervention-1 9.3; Intervention-2: 9.0; Intervention-1 8.9; Intervention-2: 9.2; Intervention-1: 9.2; Intervention-2: 9.1; OHIP: Intervention-1 6.0; Intervention-2: 10.0 VAS: Intervention-1 9.6; Intervention-2: 9.4; Intervention-1 9.3; Intervention-2: 9.4; Intervention-1 9.5; Intervention-2: 9.2; Intervention-1 9.4; Intervention-2: 8.9; Intervention-1: 9.2; Intervention-2: 9.3; VAS: Intervention-1: 8.7; Intervention-2: 9.4	PES: Intervention-1: 6.8 [1.5]; Intervention-2: 6.4 [1.5]; PES/WES: Intervention-1: 14.2 [2.4]; Intervention-2: 13.2 [2.9]; WES: Intervention-1: 7.4 [1.3]; Intervention-2: 6.9 [1.9]; PES: Intervention-1: 6.4; Intervention-2: 6.2; PES/WES: Intervention-1: 14.4; Intervention-2: 13.7; WES: Intervention-1: 8.0; Intervention-2: 7.6	Intra-oral photographs Intra-oral photographs Intra-oral photographs	BL 1M FU 1Y FU 5Y FU

Abbreviations: BL, baseline; CI, crown insertion; ClinROs, clinician-reported outcomes; FU, follow-up; ICAL, implant crown esthetic index; IOS, intra-oral scan; M, month(s); mPES, modified pink esthetic score; NR, not reported; NRS, numerical rating scale; OHIP, oral health impact profile; pat, patient; PES, pink esthetic score; PROMs, patient reported outcome measurements; RCT, randomized controlled trial; VAS, visual analogue scale; WES, white esthetic score; Y, year(s).

^aData reported as a median.

- Pink esthetic score (24/29)/modified Pink esthetic score (5/29)

Pink esthetic score (PES) was assessed in all evaluated studies. The original version (7 items, score 0–14) was reported in 24 studies (Fürhauser et al. 2005). Five trials used modified PES (PES: 5 items, score 0–10) (Belser et al. 2009). Fifteen RCTs evaluated PES at different time points, and the follow-up time ranged between 1 and 10 years.

- White esthetic score ($n=15$)

White esthetic score (WES) was reported in 15 RCTs (5 items, score 0–10) (Belser et al. 2009). Nine studies evaluated WES at different time points, and the follow-up time ranged between 1 and 10 years.

- Combined pink and white esthetic score ($n=5$)

Combined pink and white esthetic score was evaluated in five studies (PES: 5 items, score 0–10; WES: 5 items, score 0–10) (Belser et al. 2009). It was assessed in two trials at various time points, and the follow-up time ranged between 1 and 10 years.

- Implant crown esthetic index (ICAI) ($n=5$)

Implant crown esthetic index was assessed in five articles (9 items, score 0–45) (Meijer et al. 2005). Four trials reported results separately regarding crown and mucosal domains. Three RCTs evaluated ICAI at different time points, and the follow-up time ranged between 1 month and 5 years.

- Papilla index ($n=4$)

Papilla index was evaluated in four studies (5 items, score 0–4) (Jemt 1999). All trials evaluated papilla index at different time points, and the follow-up time ranged between 1 month and 10 years.

- Mucosal scarring index ($n=2$)

Mucosal scarring index was analysed in two articles (5 items, score 0–10) (Wessels et al. 2019). One RCT evaluated it in the follow-up period between 3 months and 3 years.

- Midfacial recession/mid-buccal mucosal level ($n=4$)

Midfacial recession or mid-buccal mucosal levels were evaluated in four studies. One trial evaluated it in the follow-up period between 3 months and 3 years.

- Buccal peri-implant mucosa changes at the zenith ($n=2$)

Buccal peri-implant mucosa changes at the zenith were analyzed in two trials. One study evaluated it in the follow-up period between 6 months and 1 year.

Table 3 provides detailed qualitative information on the objective ClinROs and measuring instruments used in the selected studies. One subjective ClinRO was identified for the esthetic evaluation; this was assessed by the clinician.

3.5 | Individual Participant Data (IPD) Results

The overall analysis was conducted at the patient level, focusing on single-implant-supported restorations. Data from 15 RCTs, including 700 participants, were analyzed. Fourteen studies included PES and modified PES as ClinRO measures, along with VAS and OHIP-14 as PROMs, forming the basis of the IPD meta-analysis and correlation assessments.

3.5.1 | PES and Patient Satisfaction Measured by VAS

Data from 675 patients were evaluated at different time points for PES and patient satisfaction (VAS).

- Crown insertion (baseline)

IPD from 171 patients across four RCTs showed a weak positive correlation ($r=0.11$, 95% CI $[-0.04; 0.27]$) between PES and VAS, which was not statistically significant ($p=0.16$). The data were homogeneous ($I^2=0\%$) (Figure 3).

- 6-month follow-up

Data from 122 patients between VAS and in two studies (PES) and 55 patients in one trial (modified PES) showed a negligible negative correlation ($r=-0.04$, 95% CI $[-0.19; 0.12]$) (Figure 4). No heterogeneity ($I^2=0\%$) or significant differences between PES and modified PES ($p=0.77$) were observed.

- 1-year follow-up

IPD from 502 patients in 11 studies showed a negligible positive correlation between PES or modified PES and VAS ($r=0.09$) with a trend towards statistical significance ($p=0.06$). Minimal heterogeneity ($I^2=6.3\%$) was observed across studies (Figure 5).

- 5-year follow-up

Data from 70 patients in two trials showed no correlation ($r=0.08$, 95% CI $[-0.16; 0.33]$, $p=0.50$) between PES and VAS. The findings were consistent across studies with no heterogeneity ($I^2=0\%$) (Figure 6).

- 10-year follow-up

Data from 80 patients in two studies showed a negligible negative correlation between modified PES and VAS ($r=-0.05$, 95% CI $[-0.37; 0.27]$, $p=0.75$) (Figure 7). Moderate heterogeneity ($I^2=48.39\%$) suggested variability between studies, with concerns about bias due to dropout rates according to the risk of bias assessment.

3.5.2 | WES and Patient Satisfaction Measured by VAS

- 1-year follow-Up

Data from 376 patients in seven studies showed a negligible positive correlation between WES and patient satisfaction measured

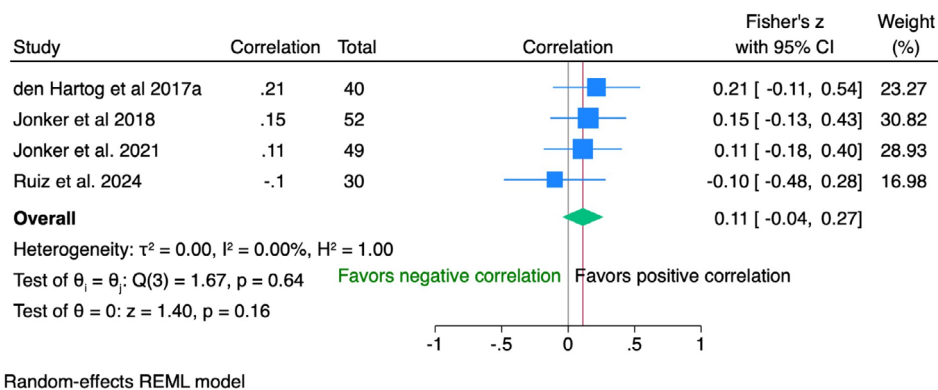


FIGURE 3 | Individual patient data meta-analysis and forest plot between patients' overall satisfaction measured by the visual analogue scale and the modified pink esthetic score (PES), measured by the clinician at crown insertion (baseline).

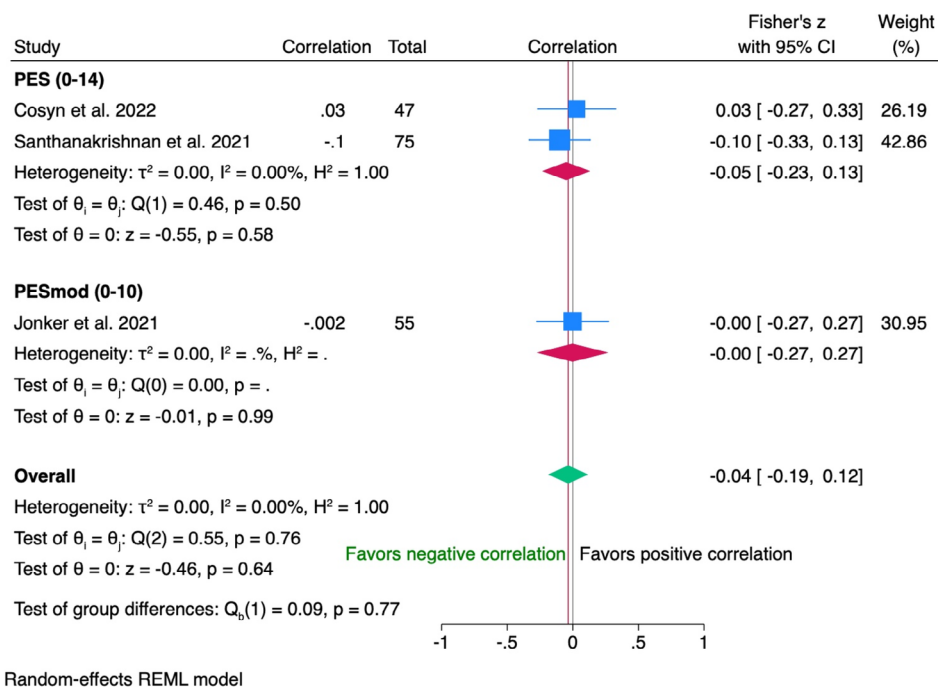


FIGURE 4 | Individual patient data meta-analysis and forest plot between patients' overall satisfaction measured by visual the analogue scale and the pink esthetic score (PES) and the modified PES, measured by the clinician at 6-month follow-up.

by VAS ($r = 0.03$, 95% CI [-0.08; 0.13], $p = 0.60$), with no heterogeneity (Figure 8).

• 10-year follow-Up

Data from 80 patients in two trials showed no significant correlations ($r = -0.01$, 95% CI [-0.23; 0.22], $p = 0.97$) between VAS and WES (Figure 9). No heterogeneity was found; though concerns about dropout-related bias exist.

3.5.3 | PES and OHIP-14 (1-Year Follow-Up)

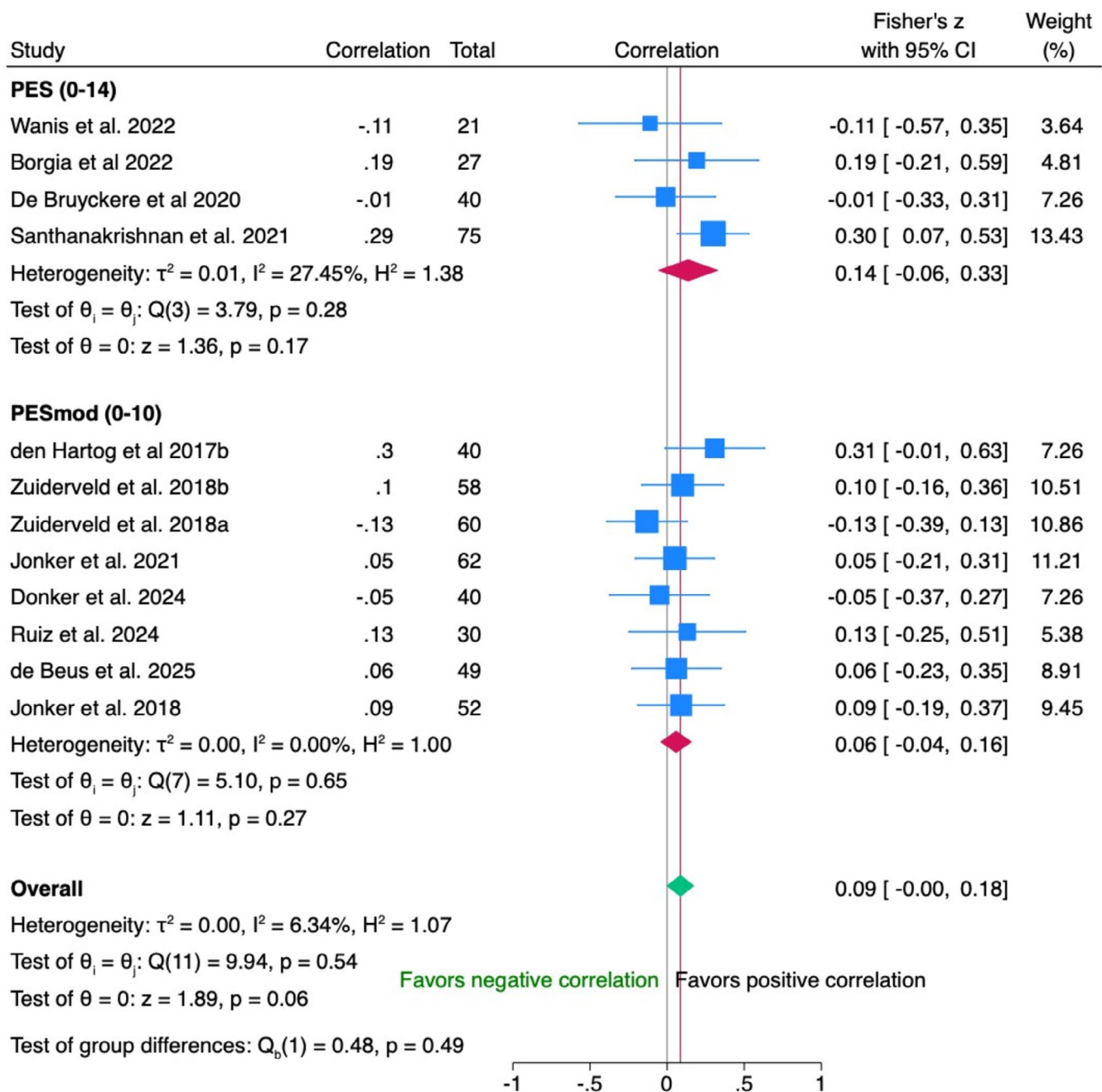
Data from 73 patients in two studies revealed a significant weak negative correlation ($r = -0.29$, 95% CI [-0.53; 0.05], $p = 0.02$) between PES and patient satisfaction measured by OHIP-14 (Figure 10). No heterogeneity was detected ($I^2 = 0\%$).

To sum up, across multiple time points, no strong or consistent correlation was found between clinician-reported esthetic outcomes (PES/WES) and patient-reported satisfaction (VAS/OHIP-14). Significant findings were limited, with concerns about bias and variability between studies.

4 | Discussion

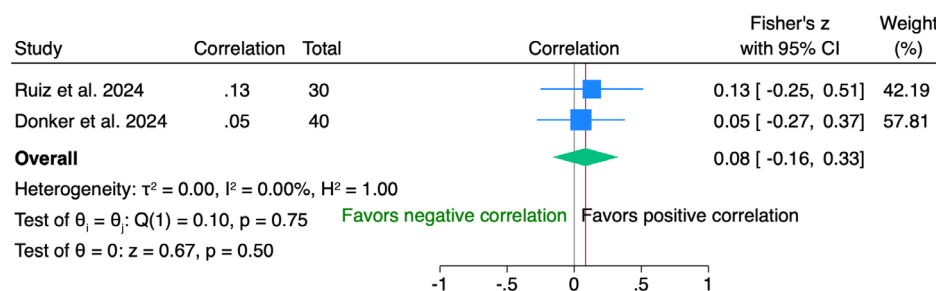
The present systematic review on single implant-supported crowns in the esthetic zone primarily revealed: (i) No correlation between patient satisfaction using VAS and PES during different follow-ups up to 10 years; (ii) a significant negative correlation between PES and OHIP-14 questionnaires.

This study used an individual participant data (IPD) meta-analysis of RCTs, a specific type of systematic review, designed



Random-effects REML model

FIGURE 5 | Individual patient data meta-analysis and forest plot between patients' overall satisfaction measured by the visual analogue scale and the pink esthetic score (PES) and the modified PESm measured by the clinician at 1-year follow-up.



Random-effects REML model

FIGURE 6 | Individual patient data meta-analysis and forest plot between patients' overall satisfaction measured by the visual analogue scale and the pink esthetic score (PES), measured by the clinician at 5-year follow-up.

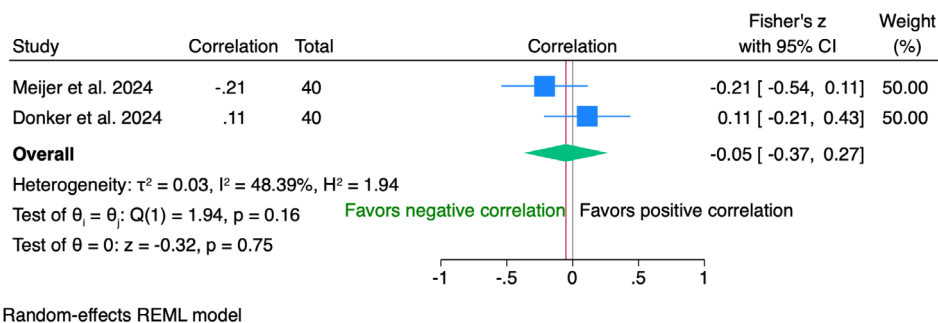


FIGURE 7 | Individual patient data meta-analysis and forest plot between patients' overall satisfaction measured by the visual analogue scale and the modified pink esthetic score (PES), measured by the clinician at 10-year follow-up.

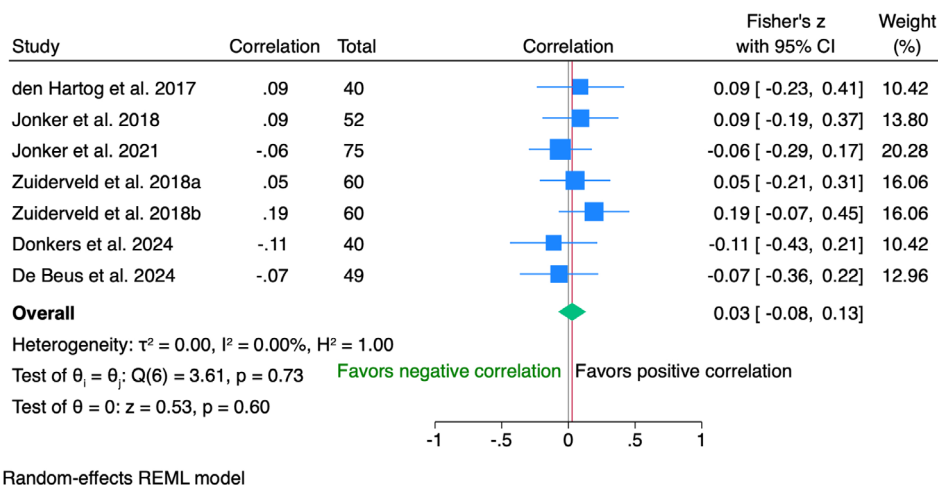


FIGURE 8 | Individual patient data meta-analysis and forest plot between patients' overall satisfaction measured by the visual analogue scale and the white esthetic score (WES), measured by the clinician at 1-year follow-up.

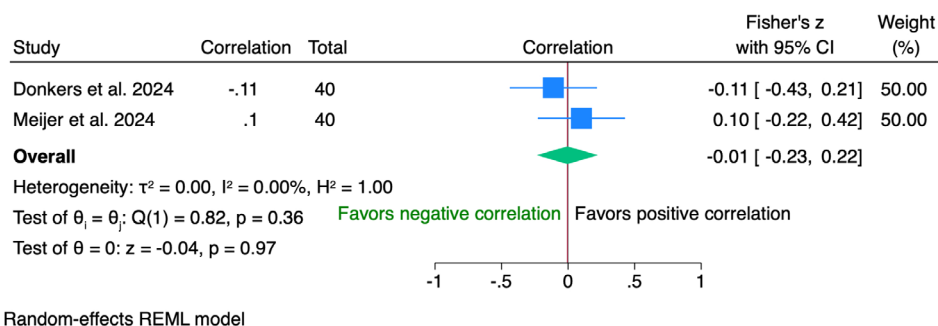


FIGURE 9 | Individual patient data meta-analysis and forest plot between patients' overall satisfaction measured by the visual analogue scale and the white esthetic score (WES), measured by the clinician at 10-year follow-up.

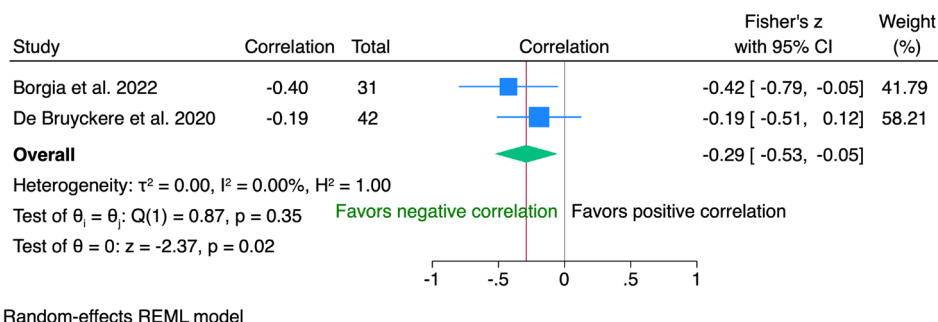


FIGURE 10 | Individual patient data meta-analysis and forest plot between the oral health impact profile (OHIP) questionnaire and the pink esthetic score (PES), measured by the clinician at 1-year follow-up.

to address a focused clinical question. Unlike traditional meta-analyses, which rely on aggregated data, IPD involves collecting, checking and reanalysing the raw individual-level data from multiple related studies. This approach allows for a more precise exploration of differential treatment effects across patients (Riley et al. 2010).

In this systematic review, IPD allowed for a more detailed exploration of individual variations in esthetics perceptions and patient satisfaction. For example, patients with similar PES scores (e.g., PES = 13) may report varying satisfaction levels, ranging from 60 mm to 90 mm on VAS scales. Traditional aggregated data meta-analysis often masks these individual variations, potentially leading to oversimplified conclusions regarding the relationship between patient and clinician-reported outcomes in esthetics (Veroniki et al. 2016). We were able to include IPD from 14 out of 29 eligible RCTs, comprising 48% of all known randomised participants. The incorporation of updated follow-up data from some trials allowed for a more precise analysis of the potential association between patient- and clinician-reported esthetic outcomes.

A previously published systematic review evaluated methods of assessment and interventions in the context of implant therapy. It highlighted that PROs were often underreported, and they needed to be incorporated as a key methodological element in future clinical research (Avila-Ortiz et al. 2023). Their importance was also mentioned in the Core Outcome Set in implant dentistry (Tonetti et al. 2023). The present review found low heterogeneity among included studies, with most of the trials conducted in university settings, with an increasing trend of PROMs assessment in more recent publications (Thoma et al. 2024). Several studies even evaluated PROMs as primary outcomes, aligning with findings from another review that observed a growing interest in assessing esthetic outcomes using both PROMs and objective indices in implant-related dentistry (De Bruyn et al. 2015). In daily practice, the association between patients and clinicians' perspectives is an important factor for decision-making and evaluation of outcomes.

Despite extensive analysis, no correlation was found between PROs and ClinROs regarding esthetics of single implant-supported crowns in this systematic review. Specifically, there was no significant correlation between patient satisfaction, measured by VAS, and PES (ClinRO) across follow-ups up to 10 years. Several factors may explain the lack of correlation. First, the available raw data for IPD were limited in sample size and varied in follow-up periods, which may have masked correlations. Second, current esthetic indices may not fully capture parameters that are important to patients, focusing instead on aspects that are less relevant to them. Third, clinicians and patients may prioritize different esthetic factors. Patients tend to focus on overall appearance and harmony, whereas dentists may focus more on the surrounding soft tissues, which are central to the PES assessment (Cosyn, Eeckhout, et al. 2021; Mancini et al. 2023). Furthermore, soft tissue augmentations that influence clinician evaluations may be less relevant to patients' perceptions (Thoma et al. 2023, Ramanuskaite et al. 2025).

In recent years, WES has become a widely used index for assessing the esthetic of single implant restorations. However, several

studies have questioned its reliability compared to other esthetic indices (Cosyn, Wessels, et al. 2021; Hof et al. 2018). In this systematic review, seven articles reported WES, and no correlation between WES and patient esthetic satisfaction was found, further underscoring the discrepancies between ClinROs and patient perception. This highlights a gap between clinician assessments and patient perceptions, which should be considered when planning and outcome evaluation.

Patient satisfaction with treatment results seems to be influenced by factors beyond esthetic outcomes alone (Fava et al. 2015). A key limitation of some included studies is the lack of blinded investigators in outcome assessments, which may introduce bias, as clinicians evaluating the outcomes often performed the treatment (e.g., positive judgement, professional relationship between patient and clinician). Moreover, ensuring patients that their responses remain confidential is essential to encourage honest and accurate reporting (Wittich et al. 2024). Clear instructions from independent investigators are essential for obtaining reliable PROs.

Different methods, timing tools and scale are used to evaluate PROs in implant-related dentistry. Historically, non-standardized paper questionnaires with Likert scales, VAS and open questions were used (Cosyn et al. 2017). While patient interviews and non-standardized questionnaires provide valuable exploratory data, their validity is limited. Consequently, comparing studies using such measures is challenging and may yield unreliable conclusions. Currently, the "Oral Health Related Quality of Life" (OHRQoL) and "Oral Health Impact Profile" (OHIP) are the only validated questionnaires used in implant dentistry. The original version of OHIP consists of 49 questions evaluating seven core areas and the shorter versions consist of 14, 20, or 21 questions. However, both standardized questionnaires primarily evaluate physical and psychological pain, functional limitations and overall quality of life rather than esthetics.

In this review, a significant negative correlation was observed when patient satisfaction was measured using OHIP-14. This inverse relationship highlights the complex interaction between specialized esthetic indices and health-related quality of life factors reported by patients. There is a clear demand to develop specifically validated questionnaires for esthetic assessments in implant dentistry.

As patient-reported outcomes become an integral part of esthetic implant treatment planning, their assessment must be standardized and anonymized to ensure they are a central component of daily practice. Notably, 10 out of 42 articles raised some concerns related to outcome measurement methods. The overall strength of evidence was rated as moderate according to GRADE guidelines (Schunemann et al. 2008). Despite its limitations, this systematic review provides relevant information into the utilization of PROs in relation to ClinROs for the esthetics of implant-supported restorations.

The present review has limitations. First, there was heterogeneity among PROs and ClinROs tools used to assess patient perception. Secondly, this review did not focus on treatment efficacy. Furthermore, by including only RCTs, valuable data

from high-quality non-randomized studies might have been excluded. Additionally, obtaining raw data from all eligible studies was challenging, with limited responses from corresponding authors. Lastly, not all the studies provided detailed information on how PROs were assessed.

From a clinician's perspective, the results of this IPD meta-analysis are frustrating. Considering all the efforts in terms of tissue regeneration (encompassing morbidity, time and costs for patients) and prosthetic adjustments (encompassing provisional crowns, several try-in sessions), the outcomes of this analysis are in strong contrast to the philosophy of how patients are informed and treated. It remains unanswered whether these surgical and prosthetic steps remain masked behind deficiencies in assessment, or whether the population is rather overtreated as a whole.

5 | Conclusions

PES and WES showed no correlation with patient satisfaction, as measured by VAS and OHIP-14, in terms of esthetics for up to 10 years after final crown placement.

Author Contributions

Sofya Sadilina: data curation, project administration, investigation, writing – original draft. **Nicolas P. A. Müller:** investigation, data curation, writing – review and editing. **Franz J. Strauss:** formal analysis, validation, visualization, writing – review and editing. **Ronald E. Jung:** conceptualization, funding acquisition, software, writing – review and editing. **Daniel S. Thoma:** conceptualization, methodology, resources, writing – review and editing. **Stefan P. Bienz:** conceptualization, methodology, resources, supervision, writing – original draft, writing – review and editing.

Acknowledgements

The authors kindly thank Prof. Jan Cosyn, Prof. Thomas De Bruyckere, Prof. Henny Meijer, Prof. Gerry Raghoobar, Prof. Muthukumar Santhanakrishnan, Dr. Ana Carillo de Albornoz, Dr. Jantien de Beus, Dr. Vincent Donker, Dr. Laurens den Hartog, Dr. Hani el Nahass, Dr. Alex Nogueira Haas, Dr. Brend Jonker, Dr. Ruben Garcia-Sanchez, Dr. Gabriel-Leonardo Magrin, Dr. Paula Andrea Ruiz Henao, Dr. Lenz Surdiacourt, Dr. Elise Zuiderveld for sharing the raw data of their study. The authors are grateful to the scientific community for providing raw data of 15 publications to enable an individual patient data meta-analysis. Open access publishing facilitated by Universitat Zurich, as part of the Wiley - Universitat Zurich agreement via the Consortium Of Swiss Academic Libraries.

Ethics Statement

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The datasets used in the study are available from the corresponding author upon reasonable request.

References

- Atef, M., A. El Barbary, M. S. E. Dahrour, and A. F. Zahran. 2021. "Comparison of the Soft and Hard Peri-Implant Tissue Dimensional Changes Around Single Immediate Implants in the Esthetic Zone With Socket Shield Technique Versus Using Xenograft: A Randomized Controlled Clinical Trial." *Clinical Implant Dentistry and Related Research* 23, no. 3: 456–465. <https://doi.org/10.1111/cid.13008>.
- Avila-Ortiz, G., E. Couso-Queiruga, M. Pirc, L. Chambrone, and D. S. Thoma. 2023. "Outcome Measures and Methods of Assessment of Soft Tissue Augmentation Interventions in the Context of Dental Implant Therapy: A Systematic Review of Clinical Studies Published in the Last 10 Years." *Journal of Clinical Periodontology* 50, no. Suppl 25: 83–95. <https://doi.org/10.1111/jcpe.13597>.
- Belser, U. C., L. Grütter, F. Vailati, M. M. Bornstein, H. P. Weber, and D. Buser. 2009. "Outcome Evaluation of Early Placed Maxillary Anterior Single-Tooth Implants Using Objective Esthetic Criteria: A Cross-Sectional, Retrospective Study in 45 Patients With a 2- to 4-Year Follow-Up Using Pink and White Esthetic Scores." *Journal of Periodontology* 80, no. 1: 140–151. <https://doi.org/10.1902/jop.2009.080435>.
- Bienz, S. P., M. Pirc, S. N. Papageorgiou, R. E. Jung, and D. S. Thoma. 2022. "The Influence of Thin as Compared to Thick Peri-Implant Soft Tissues on Aesthetic Outcomes: A Systematic Review and Meta-Analysis." *Clinical Oral Implants Research* 33, no. Suppl 23: 56–71. <https://doi.org/10.1111/clr.13789>.
- Borgia, G. S., P. Pebé, R. Barbot, and A. N. Haas. 2022. "Immediate Implants With Buccal Defects Filled With Bone From the Tuberosity or a Xenograft: 1-Year Randomized Trial." *Brazilian Oral Research* 36: e102. <https://doi.org/10.1590/1807-3107bor-2022.vol36.0102>.
- Burke, D. L., J. Ensor, and R. D. Riley. 2017. "Meta-Analysis Using Individual Participant Data: One-Stage and Two-Stage Approaches, and Why They May Differ." *Statistics in Medicine* 36, no. 5: 855–875. <https://doi.org/10.1002/sim.7141>.
- Canullo, L., M. Tallarico, D. Peñarrocha-Oltra, A. Monje, H. L. Wang, and M. Peñarrocha-Diogo. 2016. "Implant Abutment Cleaning by Plasma of Argon: 5-Year Follow-Up of a Randomized Controlled Trial." *Journal of Periodontology* 87, no. 4: 434–442. <https://doi.org/10.1902/jop.2015.150549>.
- Carrillo de Albornoz, A., F. Vignoletti, L. Ferrantino, E. Cárdenas, M. De Sanctis, and M. Sanz. 2014. "A Randomized Trial on the Aesthetic Outcomes of Implant-Supported Restorations With Zirconia or Titanium Abutments." *Journal of Clinical Periodontology* 41, no. 12: 1161–1169. <https://doi.org/10.1111/jcpe.12312>.
- Cosyn, J., C. Eeckhout, V. Christiaens, et al. 2021. "A Multi-Centre Randomized Controlled Trial Comparing Connective Tissue Graft With Collagen Matrix to Increase Soft Tissue Thickness at the Buccal Aspect of Single Implants: 3-Month Results." *Journal of Clinical Periodontology* 48, no. 12: 1502–1515. <https://doi.org/10.1111/jcpe.13560>.
- Cosyn, J., C. Eeckhout, T. De Bruyckere, et al. 2022. "A Multi-Centre Randomized Controlled Trial Comparing Connective Tissue Graft With Collagen Matrix to Increase Soft Tissue Thickness at the Buccal Aspect of Single Implants: 1-Year Results." *Journal of Clinical Periodontology* 49, no. 9: 911–921. <https://doi.org/10.1111/jcpe.13691>.
- Cosyn, J., D. S. Thoma, C. H. Hammerle, and H. De Bruyn. 2017. "Esthetic Assessments in Implant Dentistry: Objective and Subjective Criteria for Clinicians and Patients." *Periodontology 2000* 73, no. 1: 193–202. <https://doi.org/10.1111/prd.12163>.
- Cosyn, J., R. Wessels, R. Garcia Cabeza, J. Ackerman, C. Eeckhout, and V. Christiaens. 2021. "Soft Tissue Metric Parameters, Methods and Aesthetic Indices in Implant Dentistry: A Critical Review." *Clinical Oral Implants Research* 32, no. Suppl 21: 93–107. <https://doi.org/10.1111/clr.13756>.

- de Beus, J. H. W., M. S. Cune, J. W. A. Slot, et al. 2024. "A Randomized Clinical Trial on Zirconia Versus Titanium Implants in Maxillary Single Tooth Replacement." *Clinical Oral Implants Research* 35, no. 6: 630–640. <https://doi.org/10.1111/clr.14258>.
- De Bruyckere, T., J. Cosyn, F. Younes, et al. 2020. "A Randomized Controlled Study Comparing Guided Bone Regeneration With Connective Tissue Graft to Re-Establish Buccal Convexity: One-Year Aesthetic and Patient-Reported Outcomes." *Clinical Oral Implants Research* 31, no. 6: 507–516. <https://doi.org/10.1111/clr.13587>.
- De Bruyn, H., S. Raes, C. Matthyss, and J. Cosyn. 2015. "The Current Use of Patient-Centered/Reported Outcomes in Implant Dentistry: A Systematic Review." *Clinical Oral Implants Research* 26, no. Suppl 11: 45–56. <https://doi.org/10.1111/clr.12634>.
- den Hartog, L., H. J. A. Meijer, A. Vissink, and G. M. Raghoobar. 2017. "Anterior Single Implants With Different Neck Designs: 5 Year Results of a Randomized Clinical Trial." *Clinical Implant Dentistry and Related Research* 19, no. 4: 717–724. <https://doi.org/10.1111/cid.12498>.
- den Hartog, L., G. M. Raghoobar, J. J. Slater, K. Stellingsma, A. Vissink, and H. J. A. Meijer. 2013. "Single-Tooth Implants With Different Neck Designs: A Randomized Clinical Trial Evaluating the Aesthetic Outcome." *Clinical Implant Dentistry and Related Research* 15, no. 3: 311–321. <https://doi.org/10.1111/j.1708-8208.2011.00372.x>.
- den Hartog, L., G. M. Raghoobar, K. Stellingsma, A. Vissink, and H. J. A. Meijer. 2016. "Immediate Loading of Anterior Single-Tooth Implants Placed in Healed Sites: Five-Year Results of a Randomized Clinical Trial." *International Journal of Prosthodontics* 29, no. 6: 584–591. <https://doi.org/10.11607/ijp.4993>.
- Donker, V. J. J., G. M. Raghoobar, K. W. Slagter, D. F. M. Hentenaar, A. Vissink, and H. J. A. Meijer. 2024. "Immediate Implant Placement With Immediate or Delayed Provisionalization in the Maxillary Aesthetic Zone: A 10-Year Randomized Trial." *Journal of Clinical Periodontology* 51, no. 6: 722–732. <https://doi.org/10.1111/jcpe.13971>.
- Esposito, M., C. Barausse, R. Pistilli, et al. 2015. "Immediate Loading of Post-Extractive Versus Delayed Placed Single Implants in the Anterior Maxilla: Outcome of a Pragmatic Multicenter Randomised Controlled Trial 1-Year After Loading." *European Journal of Oral Implantology* 8, no. 4: 347–358.
- Esposito, M., A. González-García, M. Peñarrocha Diago, et al. 2018. "Natural or Palatal Positioning of Immediate Post-Extractive Implants in the Aesthetic Zone? 1-Year Results of a Multicentre Randomised Controlled Trial." *European Journal of Oral Implantology* 11, no. 2: 189–200.
- Fava, J., M. Lin, M. Zahran, and A. Jokstad. 2015. "Single Implant-Supported Crowns in the Aesthetic Zone: Patient Satisfaction With Aesthetic Appearance Compared With Appraisals by Laypeople and Dentists." *Clinical Oral Implants Research* 26, no. 10: 1113–1120. <https://doi.org/10.1111/clr.12412>.
- FDA-NIH Biomarker Working Group. 2016. "BEST (Biomarkers, Endpoints, and Other Tools) Resource." Silver Spring (MD): Food and Drug Administration (US). <https://www.ncbi.nlm.nih.gov/books/NBK338448/>.
- Felice, P., R. Pistilli, C. Barausse, A. Trullenque-Eriksson, and M. Esposito. 2015. "Immediate Non-Occlusal Loading of Immediate Post-Extractive Versus Delayed Placement of Single Implants in Preserved Sockets of the Anterior Maxilla: 1-Year Post-Loading Outcome of a Randomised Controlled Trial." *European Journal of Oral Implantology* 8, no. 4: 361–372.
- Felice, P., E. Soardi, M. Piattelli, R. Pistilli, M. Jacotti, and M. Esposito. 2011. "Immediate Non-Occlusal Loading of Immediate Post-Extractive Versus Delayed Placement of Single Implants in Preserved Sockets of the Anterior Maxilla: 4-Month Post-Loading Results From a Pragmatic Multicentre Randomised Controlled Trial." *European Journal of Oral Implantology* 4, no. 4: 329–344.
- Fernández, R., D. Peñarrocha-Oltra, M. Peñarrocha-Diago, J. Buti, E. Khanari, and M. Esposito. 2020. "Natural or Palatal Positioning of Immediate Post-Extraction Implants in the Aesthetic Zone? Five-Year Outcomes of a Multicentre Randomised Controlled Trial." *Clinical Trials in Dentistry* 2, no. 1: 59–71.
- Ferrantino, L., A. Carrillo de Albornoz, and M. Sanz. 2023. "Five-Year Outcomes of a Randomized Controlled Clinical Trial Comparing Single-Tooth Implant-Supported Restoration With Either Zirconia or Titanium Abutments." *Journal of Clinical Periodontology* 50, no. 6: 744–754. <https://doi.org/10.1111/jcpe.13787>.
- Fürhauser, R., D. Florescu, T. Benesch, R. Haas, G. Mailath, and G. Watzek. 2005. "Evaluation of Soft Tissue Around Single-Tooth Implant Crowns: The Pink Esthetic Score." *Clinical Oral Implants Research* 16, no. 6: 639–644. <https://doi.org/10.1111/j.1600-0501.2005.01193.x>.
- Gallucci, G. O., L. Grütter, R. Nedir, M. Bischof, and U. C. Belser. 2011. "Esthetic Outcomes With Porcelain-Fused-to-Ceramic and All-Ceramic Single-Implant Crowns: A Randomized Clinical Trial." *Clinical Oral Implants Research* 22, no. 1: 62–69. <https://doi.org/10.1111/j.1600-0501.2010.01997.x>.
- Garcia-Sanchez, R., N. Mardas, J. Buti, A. J. Ortiz Ruiz, and G. Pardo Zamora. 2021. "Immediate Implant Placement in Fresh Alveolar Sockets With a Minimal Split-Thickness Envelope Flap: A Randomised Controlled Clinical Trial." *Clinical Oral Implants Research* 32, no. 9: 1115–1126. <https://doi.org/10.1111/clr.13806>.
- Gjelvold, B., J. Kisch, B. R. Chrcanovic, T. Albrektsson, and A. Wennerberg. 2017. "Clinical and Radiographic Outcome Following Immediate Loading and Delayed Loading of Single-Tooth Implants: Randomized Clinical Trial." *Clinical Implant Dentistry and Related Research* 19, no. 3: 549–558. <https://doi.org/10.1111/cid.12479>.
- Guyatt, G. H., A. D. Oxman, R. Kunz, et al. 2011. "GRADE Guidelines: 7. Rating the Quality of Evidence—Inconsistency." *Journal of Clinical Epidemiology* 64, no. 12: 1294–1302. <https://doi.org/10.1016/j.jclinepi.2011.03.017>.
- Hassani, A., M. Hassani, and T. Bitaraf. 2021. "Immediate vs. Delayed Restorations of Immediately Placed Single Implants in the Anterior Maxilla: A Nonrandomized Clinical Study." *International Journal of Oral & Maxillofacial Implants* 36, no. 6: 1159–1164. <https://doi.org/10.11607/jomi.8947>.
- Henao, P. A. R., G. L. Magrin, L. Caneiro-Queija, et al. 2024. "Single-Piece Zirconia Versus Single-Piece Titanium, Narrow-Diameter Dental Implants in the Anterior Maxilla: 5-Year Post-Loading Results of a Randomized Clinical Trial." *Clinical Oral Implants Research* 35, no. 10: 1310–1323. <https://doi.org/10.1111/clr.14319>.
- Higgins, J. P., and S. G. Thompson. 2002. "Quantifying Heterogeneity in a Meta-Analysis." *Statistics in Medicine* 21, no. 11: 1539–1558. <https://doi.org/10.1002/sim.1186>.
- Higgins, J. P. T., J. Chandler, M. Cumpston, T. Li, M. J. Page, and V. A. Welch. 2021. "Cochrane Handbook for Systematic Reviews of Interventions Version 6.2." www.training.cochrane.org/handbook.
- Hof, M., N. Umar, N. Budas, R. Seemann, B. Pommer, and W. Zechner. 2018. "Evaluation of Implant Esthetics Using Eight Objective Indices—Comparative Analysis of Reliability and Validity." *Clinical Oral Implants Research* 29, no. 7: 697–706. <https://doi.org/10.1111/clr.13261>.
- Jemt, T. 1999. "Restoring the Gingival Contour by Means of Provisional Resin Crowns After Single-Implant Treatment." *International Journal of Periodontics & Restorative Dentistry* 19, no. 1: 20–29.
- Johnston, B. C., D. L. Patrick, T. Devji, L. J. Maxwell, D. E. Beaton, and G. H. Guyatt. 2019. "Patient-Reported Outcomes." In *Cochrane Handbook for Systematic Reviews of Interventions*, 479–492. Cochrane.
- Jonker, B. P., F. J. Strauss, N. Naenni, R. E. Jung, E. B. Wolvius, and J. Pijpe. 2021. "Early Implant Placement With or Without Alveolar Ridge Preservation in Single Tooth Gaps Renders Similar Esthetic, Clinical and Patient-Reported Outcome Measures: One-Year Results of

- a Randomized Clinical Trial." *Clinical Oral Implants Research* 32, no. 9: 1041–1051. <https://doi.org/10.1111/clr.13796>.
- Jonker, B. P., E. B. Wolvius, J. T. van der Tas, and J. Pijpe. 2018. "The Effect of Resorbable Membranes on One-Stage Ridge Augmentation in Anterior Single-Tooth Replacement: A Randomized, Controlled Clinical Trial." *Clinical Oral Implants Research* 29, no. 2: 235–247. <https://doi.org/10.1111/clr.13106>.
- Mancini, L., S. Barootchi, D. S. Thoma, et al. 2023. "The Peri-Implant Mucosa Color: A Systematic Appraisal of Methods for Its Assessment and Clinical Significance." *Clinical Implant Dentistry and Related Research* 25, no. 2: 224–240. <https://doi.org/10.1111/cid.13180>.
- McGrath, C., O. Lam, and N. Lang. 2012. "An Evidence-Based Review of Patient-Reported Outcome Measures in Dental Implant Research Among Dentate Subjects." *Journal of Clinical Periodontology* 39, no. Suppl 12: 193–201. <https://doi.org/10.1111/j.1600-051X.2011.01841.x>.
- Meijer, H. J., K. Stellingsma, L. Meijndert, and G. M. Raghoobar. 2005. "A New Index for Rating Aesthetics of Implant-Supported Single Crowns and Adjacent Soft Tissues—The Implant Crown Aesthetic Index." *Clinical Oral Implants Research* 16, no. 6: 645–649. <https://doi.org/10.1111/j.1600-0501.2005.01128.x>.
- Meijer, H. J. A., K. W. Slagter, B. Gareb, D. F. M. Hentenaar, A. Vissink, and G. M. Raghoobar. 2024. "Immediate Single-Tooth Implant Placement in Bony Defect Sites: A 10-Year Randomized Controlled Trial." *Journal of Periodontology* 96: 151–163. <https://doi.org/10.1002/jper.24-0251>.
- Meijndert, L., H. J. Meijer, K. Stellingsma, B. Stegenga, and G. M. Raghoobar. 2007. "Evaluation of Aesthetics of Implant-Supported Single-Tooth Replacements Using Different Bone Augmentation Procedures: A Prospective Randomized Clinical Study." *Clinical Oral Implants Research* 18, no. 6: 715–719. <https://doi.org/10.1111/j.1600-0501.2007.01415.x>.
- Peñarrocha-Oltra, D., M. Peñarrocha-Diago, R. F. Encinas, D. R. Ippolito, E. Khanari, and M. Esposito. 2019. "Natural or Palatal Positioning of Immediate Post-Extractive Implants in the Aesthetic Zone? Three-Year Results of a Multicentre Randomised Controlled Trial." *International Journal of Oral Implantology* 12, no. 2: 181–194.
- Pjetursson, B. E., A. G. Asgeirsson, M. Zwahlen, and I. Sailer. 2014. "Improvements in Implant Dentistry Over the Last Decade: Comparison of Survival and Complication Rates in Older and Newer Publications." *International Journal of Oral & Maxillofacial Implants* 29: 308–324. <https://doi.org/10.11607/jomi.2014suppl.g5.2>.
- Poepl, N., S. Schreml, F. Lichtenegger, A. Lenich, M. Eisenmann-Klein, and L. Prantl. 2007. "Does the Surface Structure of Implants Have an Impact on the Formation of a Capsular Contracture?" *Aesthetic Plastic Surgery* 31, no. 2: 133–139. <https://doi.org/10.1007/s00266-006-0091-y>.
- Powers, J. H., 3rd, D. L. Patrick, M. K. Walton, et al. 2017. "Clinician-Reported Outcome Assessments of Treatment Benefit: Report of the ISPOR Clinical Outcome Assessment Emerging Good Practices Task Force." *Value in Health* 20, no. 1: 2–14. <https://doi.org/10.1016/j.jval.2016.11.005>.
- Ramanuskaite, A., S. Sadilina, F. Schwarz, E. Cafferata, F. Strauss, and D. Thoma. 2025. "Soft-Tissue Volume Augmentation During Early, Delayed and Late Dental Implant Therapy: A Systematic Review and Meta-Analysis on Professionally-Determined Aesthetics and Self-Reported Patient Satisfaction on Aesthetics." *Clinical Oral Implants Research*.
- Riley, R. D., P. C. Lambert, and G. Abo-Zaid. 2010. "Meta-Analysis of Individual Participant Data: Rationale, Conduct, and Reporting." *BMJ (Clinical Research Ed.)* 340: c221. <https://doi.org/10.1136/bmj.c221>.
- Rosner, B., and R. J. Glynn. 2007. "Interval Estimation for Rank Correlation Coefficients Based on the Probit Transformation With Extension to Measurement Error Correction of Correlated Ranked Data." *Statistics in Medicine* 26, no. 3: 633–646. <https://doi.org/10.1002/sim.2547>.
- Ruiz Henao, P. A., L. Caneiro Queija, S. Mareque, A. Tasende Pereira, A. Liñares González, and J. Blanco Carrión. 2021. "Titanium vs. Ceramic Single Dental Implants in the Anterior Maxilla: A 12-Month Randomized Clinical Trial." *Clinical Oral Implants Research* 32, no. 8: 951–961. <https://doi.org/10.1111/clr.13788>.
- Sadilina, S., S. H. Park, J. Chantler, et al. 2024. "Immediate Loading of Definitive Restorations in Partially Edentulous Patients Requiring an Implant-Supported Prosthesis: A Scoping Review." *Journal of Prosthetic Dentistry*. <https://doi.org/10.1016/j.prosdent.2024.04.013>.
- Santhanakrishnan, M., V. Subramanian, D. Arul, and S. V. Marimuthu. 2024. "Evaluation of Timing of Implant Placement in Maxillary Esthetic Zone With Type I Extraction Sockets- A Randomized Controlled Trial." *Clinical, Cosmetic and Investigational Dentistry* 16: 481–498. <https://doi.org/10.2147/ccide.S489867>.
- Santhanakrishnan, M., V. Subramanian, N. Ramesh, and R. Kamaleeshwari. 2021. "Radiographic and Esthetic Evaluation Following Immediate Implant Placement With or Without Socket Shield and Delayed Implant Placement Following Socket Preservation in the Maxillary Esthetic Region—A Randomized Controlled Clinical Trial." *Clinical, Cosmetic and Investigational Dentistry* 13: 479–494. <https://doi.org/10.2147/CCIDE.S332687>.
- Schober, P., C. Boer, and L. A. Schwarte. 2018. "Correlation Coefficients: Appropriate Use and Interpretation." *Anesthesia and Analgesia* 126, no. 5: 1763–1768. <https://doi.org/10.1213/ANE.0000000000002864>.
- Schunemann, H. J., A. D. Oxman, J. Brozek, P. Glasziou, R. Jaeschke, and G. E. Vist. 2008. "Grading Quality of Evidence and Strength of Recommendations for Diagnostic Tests and Strategies." *BMJ (Clinical Research Ed.)* 336, no. 7653: 1106–1110. <https://doi.org/10.1136/bmj.39500.677199.AE>.
- Slagter, K. W., H. J. Meijer, N. A. Bakker, A. Vissink, and G. M. Raghoobar. 2016. "Immediate Single-Tooth Implant Placement in Bony Defects in the Esthetic Zone: A 1-Year Randomized Controlled Trial." *Journal of Periodontology* 87, no. 6: 619–629. <https://doi.org/10.1902/jop.2016.150417>.
- Slagter, K. W., H. J. A. Meijer, N. A. Bakker, A. Vissink, and G. M. Raghoobar. 2015. "Feasibility of Immediate Placement of Single-Tooth Implants in the Aesthetic Zone: A 1-Year Randomized Controlled Trial." *Journal of Clinical Periodontology* 42, no. 8: 773–782. <https://doi.org/10.1111/jcpe.12429>.
- Slagter, K. W., H. J. A. Meijer, D. F. M. Hentenaar, A. Vissink, and G. M. Raghoobar. 2021. "Immediate Single-Tooth Implant Placement With Simultaneous Bone Augmentation Versus Delayed Implant Placement After Alveolar Ridge Preservation in Bony Defect Sites in the Esthetic Region: A 5-Year Randomized Controlled Trial." *Journal of Periodontology* 92, no. 12: 1738–1748. <https://doi.org/10.1002/jper.20-0845>.
- Sterne, J. A. C., J. Savovic, M. J. Page, et al. 2019. "RoB 2: A Revised Tool for Assessing Risk of Bias in Randomised Trials." *BMJ* 366: l4898. <https://doi.org/10.1136/bmj.l4898>.
- Stewart, L. A., M. Clarke, M. Rovers, et al. 2015. "Preferred Reporting Items for Systematic Review and Meta-Analyses of Individual Participant Data: The PRISMA-IPD Statement." *JAMA* 313, no. 16: 1657–1665. <https://doi.org/10.1001/jama.2015.3656>.
- Studer, S., U. Zellweger, and P. Scharer. 1996. "The Aesthetic Guidelines of the Mucogingival Complex for Fixed Prosthodontics." *Practical Periodontics and Aesthetic Dentistry* 8, no. 4: 333–341.
- Surdiacourt, L., V. Christiaens, T. Bruyckere, et al. 2024. "A Multi-Centre Randomized Controlled Trial Comparing Connective Tissue Graft With Collagen Matrix to Increase Soft Tissue Thickness at the Buccal Aspect of Single Implants: 3-Year Results." *Journal of Clinical Periodontology* 52: 92–101. <https://doi.org/10.1111/jcpe.13975>.

- Thoma, D., A. Gil, T. de Bruyckere, et al. 2024. "Early Implant Placement Versus Ridge Preservation and Delayed Implant Placement: Analysis of Profilometric, Clinician- and Patient-Reported Outcomes From a Two-Centre RCT." *Clinical Oral Implants Research* 35: 1382–1393. <https://doi.org/10.1111/clr.14325>.
- Thoma, D. S., and F. J. Strauss. 2022. "On the Discrepancy Between Professionally Assessed and Patient-Reported Outcome Measures." *Journal Periodontal Implant Science* 52, no. 2: 89–90. <https://doi.org/10.5051/jpis.225202edi01>.
- Thoma, D. S., F. J. Strauss, L. Mancini, T. J. W. Gasser, and R. E. Jung. 2023. "Minimal Invasiveness in Soft Tissue Augmentation at Dental Implants: A Systematic Review and Meta-Analysis of Patient-Reported Outcome Measures." *Periodontology 2000* 91, no. 1: 182–198. <https://doi.org/10.1111/prd.12465>.
- Tonetti, M. S., M. Sanz, G. Avila-Ortiz, et al. 2023. "Relevant Domains, Core Outcome Sets and Measurements for Implant Dentistry Clinical Trials: The Implant Dentistry Core Outcome Set and Measurement (ID-COSM) International Consensus Report." *Journal of Clinical Periodontology* 50, no. Suppl 25: 5–21. <https://doi.org/10.1111/jcpe.13808>.
- U.S. Food and Drug Administration, F. 2021a. "Division of Clinical Outcome Assessment (DCOA)."
- U.S. Food and Drug Administration, F. 2021b. "Guidance for Industry: Patient-Reported Outcome Measures: Use in Medical Product Development to Support Labeling Claims."
- Vazouras, K., H. Gholami, M. Margvelashvili-Malament, Y. J. Kim, M. Finkelman, and H. P. Weber. 2022. "An Esthetic Evaluation of Different Abutment Materials in the Anterior Maxilla: A Randomized Controlled Clinical Trial Using a Crossover Design." *Journal of Prosthodontics* 31, no. 8: 673–680. <https://doi.org/10.1111/jopr.13520>.
- Veroniki, A. A., D. Jackson, W. Viechtbauer, et al. 2016. "Methods to Estimate the Between-Study Variance and Its Uncertainty in Meta-Analysis." *Research Synthesis Methods* 7, no. 1: 55–79. <https://doi.org/10.1002/jrsm.1164>.
- Wanis, R. W., M. M. Hosny, and H. ElNahass. 2022. "Clinical Evaluation of the Buccal Aspect Around Immediate Implant Using Dual Zone Therapeutic Concept Versus Buccal Gap Fill to Bone Level: A Randomized Controlled Clinical Trial." *Clinical Implant Dentistry and Related Research* 24, no. 3: 307–319. <https://doi.org/10.1111/cid.13091>.
- Wessels, R., S. De Roose, T. De Bruyckere, et al. 2019. "The Mucosal Scarring Index: Reliability of a New Composite Index for Assessing Scarring Following Oral Surgery." *Clinical Oral Investigations* 23, no. 3: 1209–1215. <https://doi.org/10.1007/s00784-018-2535-6>.
- Wittich, L., C. Tsatsaronis, D. Kuklinski, et al. 2024. "Patient-Reported Outcome Measures as an Intervention: A Comprehensive Overview of Systematic Reviews on the Effects of Feedback." *Value in Health* 27, no. 10: 1436–1453. <https://doi.org/10.1016/j.jval.2024.05.013>.
- Wittneben, J. G., D. Wismeijer, U. Brägger, T. Joda, and S. Abou-Ayash. 2018. "Patient-Reported Outcome Measures Focusing on Aesthetics of Implant- and Tooth-Supported Fixed Dental Prostheses: A Systematic Review and Meta-Analysis." *Clinical Oral Implants Research* 29, no. Suppl 16: 224–240. <https://doi.org/10.1111/clr.13295>.
- Wittneben, J. G., B. Yilmaz, D. Wismeijer, S. Shahdad, U. Brägger, and S. Abou-Ayash. 2023. "Patient-Reported Outcome Measures Focusing on the Esthetics of Implant-Compared to Tooth-Supported Single Crowns-A Systematic Review and Meta-Analysis." *Journal of Esthetic and Restorative Dentistry* 35, no. 4: 632–645. <https://doi.org/10.1111/jerd.12983>.
- Younes, F., A. Eghbali, T. Goemaere, T. De Bruyckere, and J. Cosyn. 2018. "Patient-Reported Outcomes After Lateral Wall Sinus Floor Elevation: A Systematic Review." *Implant Dentistry* 27, no. 2: 236–245. <https://doi.org/10.1097/ID.0000000000000717>.
- Zamora, G. P., J. M. Molina-González, J. F. Martínez-Marco, A. J. O. Ruiz, N. Mardas, and R. Garcia-Sanchez. 2024. "Aesthetic Outcomes of Different Materials for Delayed, Single-Tooth Restorations for Immediately Placed Implants. A Randomized Controlled Clinical Trial." *Journal of Dentistry* 146: 105067. <https://doi.org/10.1016/j.jdent.2024.105067>.
- Zuiderveld, E. G., H. J. A. Meijer, L. den Hartog, A. Vissink, and G. M. Raghoobar. 2018b. "Effect of Connective Tissue Grafting on Peri-Implant Tissue in Single Immediate Implant Sites: A RCT." *Journal of Clinical Periodontology* 45, no. 2: 253–264. <https://doi.org/10.1111/jcpe.12820>.
- Zuiderveld, E. G., H. J. A. Meijer, B. Gareb, A. Vissink, and G. M. Raghoobar. 2024. "Single Immediate Implant Placement in the Maxillary Aesthetic Zone With and Without Connective Tissue Grafting: Results of a 5-Year Randomized Controlled Trial." *Journal of Clinical Periodontology* 51, no. 4: 487–498. <https://doi.org/10.1111/jcpe.13918>.
- Zuiderveld, E. G., H. J. A. Meijer, A. Vissink, and G. M. Raghoobar. 2018a. "The Influence of Different Soft-Tissue Grafting Procedures at Single Implant Placement on Esthetics: A Randomized Controlled Trial." *Journal of Periodontology* 89, no. 8: 903–914. <https://doi.org/10.1002/jper.18-0061>.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** clr70019-sup-0001-supinfo.docx.