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REVIEW ARTICLE

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Patient-reported outcome measures focusing on aesthetics of implant- and tooth-supported fixed dental prostheses: A systematic review and meta-analysis

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Abstract

Objectives: The aim of this systematic review and meta-analysis was to summarize the existing evidence on patient-reported aesthetic outcome measures (PROMs) of implant-supported, relative to tooth-supported fixed dental prostheses.

Material and Methods: In April 2017, two reviewers independently searched the Medline (PubMed), EMBASE, and Cochrane electronic databases, focusing on studies including patient-reported aesthetic outcomes of implant- and tooth-supported fixed dental prostheses (FDPs). Human studies with a mean follow-up period of at least 1 year, a minimum of ten patients, and English, German, or French publication were included. For the comparison of subgroups, random-effects meta-regression for aggregate-level data was used.

Results: The systematic search for implant-supported prostheses focusing on patient-reported outcomes identified 2,675 titles, which were screened by two independent authors. Fifty full-text articles were analyzed, and finally, 16 publications (including 19 relevant study cohorts) were included. For tooth-supported prostheses, no studies could be included. A total of 816 implant-supported reconstructions were analyzed by patients. Overall aesthetic evaluation by the patients' visual analogue scale (VAS) rating was high in implant-supported FDPs (median: 90.3; min–max: 80.0–94.0) and the surrounding mucosa (median: 84.7; min–max: 73.0–92.0). Individual restorative materials, implant neck design (i.e., tissue or bone level type implants), and the use of a fixed provisional had no effect on patients' ratings of the definitive implant-supported FDPs.

Conclusions: Aesthetics is an important patient-reported measure, which lacks in standardized methods; however, patients' satisfaction was high for implant-supported FDPs and the surrounding mucosa.

KEYWORDS

esthetic, FDP, implant, implant-supported crown, Mucosa, patient-centered outcomes, patient-reported outcomes, PROM, PROMS, VAS

1 | INTRODUCTION

In the field of fixed prosthodontics, various assessment methods have been used to evaluate the aesthetic outcome. A distinction is made between objective and subjective criteria. Objective criteria are said to be neutral and free of any value by the evaluating person, resulting in reproducible measurements regardless of the person performing the evaluation, whereas subjective criteria

always include an influence by the judging person (De Bruyn, Raes, Matthys, & Cosyn, 2015).

Objective indices are particularly suitable for the comparison of treatment outcomes in clinical studies (Meijer, Stellingsma, Meijndert, & Raghoebar, 2005) or their application for clinical dental education (Lang, Zitzmann, Working Group 3 of the VIII European Workshop on Periodontology, 2012). Various indices have been introduced for aesthetic assessments (Belser et al., 2009; Fürhauser et al., 2005; Jemt, 1997; Meijer et al., 2005). However, even with those objective criteria, 100% exact reproducibility is rare. This even applies to the pink aesthetic score/white aesthetic score (PES/WES) (Belser et al., 2009), an objective index demonstrating the highest repeatability among all objective aesthetic indices (Tettamanti et al., 2016). However, the results vary with different examiners (den Hartog, Raghoebar, Stellingsma, Vissink, & Meijer, 2011). Even the same person reevaluating a situation at a second-time point might report a non-identical result (Schropp & Isidor, 2007).

As the influence of individual grading may vary among examiners, comparing the results of subjective evaluations is a very difficult task. The amount of grading depends on several factors, for example on the level of clinical training of each examiner (Gehrke, Degidi, Lulay-Saad, & Dhom, 2009; Meijer et al., 2005). Comparing the judgment of the aesthetic treatment outcome of lay persons and dental professionals, the ratings of lay persons are higher (Belser et al., 2009; Chang, Odman, Wennström, & Andersson, 1999; Meijndert, Meijer, Stellingsma, Stegenga, & Raghoebar, 2007). But, there are many more factors influencing the individual perception of aesthetics, such as social environment, education, or cultural background.

Patient-reported outcome measures (PROMs) are among the most frequently used subjective assessments in clinical investigations. Compared to earlier studies, the use of PROMs in general medicine has emerged, leading to a paradigm shift to "patient-centered care" (Marshall, Haywood, & Fitzpatrick, 2006). This trend can also be observed in dental medicine (Buck & Newton, 2001; Derks, Håkansson, Wennström, Klinge, & Berglundh, 2015; McGrath, Lam, & Lang, 2012). Taking into account that patient satisfaction is one of the major goals in every medical discipline, this evolution seems logical (De Bruyn et al., 2015).

One such PROM, which has moved to the forefront of dental medicine, is patients' estimation of the aesthetic outcome after prosthodontic treatment. Pleasing aesthetics in reconstructive dentistry is defined by the harmonic appearance of natural and adjacent restored teeth and soft tissue (Belser, Buser, & Higginbottom, 2004; Belser, Schmid, Higginbottom, & Buser, 2004). The scientific literature reflects this phenomenon, as the majority of studies treating aesthetic aspects of implant dentistry have been published in the last decade (Cosyn, Thoma, Hämmerle, & De Bruyn, 2017).

In partially edentulous patients demanding a fixed rehabilitation, the choice between tooth- or implant-supported fixed dental prostheses (FDPs) needs to be made. To obtain an overview with respect to the most aesthetic treatment preference according to patients, the aim of the performed literature screening was to extract PROM data from clinical studies by means of a systematic review protocol.

Today, various assessment methods exist in the form of scales or questionnaires used to acquire these data (Buck & Newton, 2001; McGrath et al., 2012). However, a standardized approach for the evaluation of PROMs is still lacking. Therefore, the results of studies using different assessment methods are hardly comparable. One of the most widely used assessment methods for PROMs in dentistry are visual analogue scales (VAS), but their application has also been criticized (Schabel, McNamara, Franchi, & Baccetti, 2009; Torrance, Feeny, & Furlong, 2001). But at least a high number of studies using VAS for PROM evaluation can be expected. Therefore, the aim of this systematic review and meta-analysis was to analyze the aesthetic results of implant-supported relative to tooth-supported FDPs according to patient-reported outcomes assessed by VAS. The results should improve understanding of patient demands in aesthetic treatment and patient satisfaction with treatment outcomes. Furthermore, the influence of restoration material, implant type, and provisional phase on PROMs, focusing on implant- and tooth-supported FDPs was analyzed.

2 | MATERIAL AND METHODS

2.1 | Definition of terms

2.1.1 | Patient-reported outcome measures (PROMs)

In dental medicine, the term "patient reported outcome measures" (PROMs) was introduced in the 8th European Workshop on Periodontology. These essentially include "subjective" reports of patients' perceptions of their oral health status and its impact on their daily life or quality of life, reports of satisfaction with oral health status, and/or oral health care and other nonclinical assessments (Cosyn et al., 2017; Lang et al., 2012; McGrath, Lam, & Lang, 2012).

2.1.2 | Visual analogue scale (VAS)

A visual analogue scale (VAS) is an instrument used to quantify a subjective experience (e.g., treatment outcome). Commonly used VAS are lines of 10 cm, labeled with worst experience (worst treatment outcome) at one end, and best experience (best treatment outcome) on the other end, without any further markings. Patients are instructed to mark the line according to their actual feeling. The clinician measures the distance of the mark from the beginning of the line and calculates a percent value according to the position of the marking.

2.2 | Study protocol

The study protocol for this systematic review was registered in the PROSPERO database. It was set in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (Moher, Liberati, Tetzlaff, & Altman, 2009) (for PRISMA checklist, see Supporting Information). The focused leading question was set according to the P.I.C.O. model for clinical questions. The four criteria according to the P.I.C.O. model were as follows:

Population: Partially edentulous patients
Intervention: Implant-supported FDPs
Comparison: Tooth-supported FDPs
Outcome: Patient-reported outcomes (PROMs), measured with VAS

The resulting P.I.C.O. question was: "In partially edentulous patients, what are the aesthetic results of implant-supported compared to tooth-supported fixed dental prostheses using patient-reported outcomes."

2.3 | Eligibility criteria

For the systematic literature searches, an overview of the inclusion and exclusion criteria was provided in Tables 1 and 2.

Inclusion and exclusion criteria were as follows:

2.3.1 | Inclusion

- Human clinical studies (randomized controlled trials, controlled trials, prospective studies, retrospective studies, case series)
- Partially edentulous patients
- Tooth- or implant-supported FDPs
- Documentation of PROMs by VAS
- Number of patients per study arm or cohort ≥10
- Mean follow-up period ≥1 years
- Publication in English, German, or French

2.3.2 | Exclusion

- In vitro or animal studies
- Removable partial dentures
- Edentulous patients
- Fully dentate patients
- Insufficient documentation PROMs
- Fewer than 10 patients in relevant study arm/cohort
- Mean follow-up period <1 year
- Combined tooth-implant-supported restorations
- Studies not written in English, German, or French

TABLE 1 Systematic search strategy- implant-supported reconstruction

Focused question (PICO)	**In partially edentulous patients, what are the aesthetic results of implant-supported compared to tooth-supported fixed dental prostheses using patient-reported outcomes**	
Search Strategy	Population	#1 "partially edentulous" OR edentulous OR jaw OR "partially edentulous" OR "partial edentulism" OR edentulous [Mesh Term]
	Intervention or exposure	#2 implant OR crown OR reconstruct* OR FPD OR implant crown* OR Implant bridge* OR "implant supported prosthesis" OR "implant supported crown"
	Comparison	#3 "tooth supported prosthesis" OR tooth-supported OR bridge* OR fixed partial denture* OR FPD* OR crown
	Outcome	#4 aesthetic OR evaluation OR aesthetic* OR VAS OR questionnaire* OR "patient related" OR "patient reported outcome" OR "patient opinion" OR "patient perception" OR "patient report"
	Search combination	#1 AND #2 AND #3 AND # 4
Database search	Electronic	PubMed, Cochrane Central Register of Controlled Trials (CENTRAL)
	Journals	Clinical Oral Implants Research, International Journal of Oral Maxillofacial Implants, Clinical Implant Dentistry and Related Research, Implant Dentistry, Journal of Implantology, Journal of Periodontology, Journal of Clinical Periodontology
Selection criteria	Inclusion criteria	• Human clinical studies (randomized controlled trials, controlled trials, prospective studies, retrospective studies, case series) • Partially edentulous patients • Tooth or implant-supported FDPs • Documentation of PROMs • Number of patients/study arm or cohort ≥ 10 • Mean follow-up period ≥ 1 years • Publication in English, German or French
	Exclusion criteria	• In vitro or animal studies • Removable partial dentures • Edentulous patients • Fully dentate patients • Insufficient documentation PROMs • Fewer than 10 patients in relevant study arm/cohort • Mean follow-up period less than 1 year • Publications not written in English • Combined tooth-implant-supported restorations • Studies not written in English, German or French

TABLE 2 Systematic search strategy, exclusively looking for tooth-supported restorations

Focused question (PICO)	In partially edentulous patients, what are the aesthetic results of implant-supported compared to tooth-supported fixed dental prostheses using patient-reported outcomes'	
Search strategy	Population	#1 "partially edentulous" OR edentulous OR jaw OR "partially edentulous" OR "partial edentulism" OR edentulous [Mesh Term]
	Intervention or exposure	#2 "tooth-supported prosthesis" OR bridge* OR fixed partial denture* OR FPD OR SC OR crown OR crown [Mesh Term] OR fixed partial denture [Mesh Term]
	Comparison	
	Outcome	#3 aesthetic OR evaluation OR aesthetic* OR VAS OR questionnaire* OR "patient related" OR "patient reported outcome" OR "patient opinion' OR "patient perception" OR "patient report"
	Search combination	#1 AND #2 AND #3
Database search	Electronic	PubMed
	Journals	Clinical Oral Implants Research, International Journal of Oral Maxillofacial Implants, Clinical Implant Dentistry and Related Research, Implant Dentistry, Journal of Implantology, Journal of Periodontology, Journal of Clinical Periodontology
Selection criteria	Inclusion criteria	• Human clinical studies (randomized controlled trials, controlled trials, prospective studies, retrospective studies, case series) • Partially edentulous patients • Tooth-supported FDPs • Documentation of PROMs • Number of patients/study arm or cohort ≥10 • Mean follow-up period ≥1 years • Publication in English, German or French
	Exclusion criteria	• In vitro or animal studies • Removable partial dentures • Edentulous patients • Fully dentate patients • Insufficient documentation PROMs • Fewer than 10 patients in relevant study arm/cohort • Mean follow-up period less than 1 year • Publications not written in English • Combined tooth-implant-supported restorations • Studies not written in English, German or French

2.4 | Search strategy and study selection

For the initial electronic search in the MEDLINE (via PubMed), EMBASE, and COCHRANE libraries, a systematic search term for an initial search was developed (Table 1). All libraries were scanned for related literature without using any filters. Furthermore, reference lists of related articles with similar topics were systematically screened, and potentially relevant articles were added to the results of the electronic search. After eliminating duplicates, the titles of the remaining articles were checked for adequacy, according to the inclusion criteria. Irrelevant titles (e.g., in vitro studies) were excluded. If the relevance of a study was indecisive according to the title, it was included for abstract screening. If the abstract was also inconclusive, the study was included for full-text screening, resulting in a selection of eligible full texts. After reviewing the full texts, irrelevant articles were excluded, and data from the remaining articles were extracted whenever possible. Study selection and data extraction were performed independently for each step by two reviewers (JW, SA). Disagreement regarding the inclusion of specific articles was solved by discussion. If multiple relevant study arms or cohorts were identified in the same study, data from each group were recorded separately (e.g., different restoration materials). This resulted in a higher number of study populations than indicated by the number of included studies.

After data extraction, no study for the comparison group (tooth-supported FDPs) could be identified. Therefore, a second systematic search of the literature was carried out, exclusively looking for articles on tooth-supported FDPs. It was performed as outlined above. The applied systematic search strategies can be seen in Tables 1 and 2.

For data extraction, the study form included the following parameters: authors, year of publication, study design, type of support (tooth/implant), type of retention (screw/cement), mean follow-up, type of FDP, planned number of patients, actual number of patients, mean age, age range, setting, total failure of FDPs, PROMs mucosa, PROMs restoration, restoration material, implant type, implant brand, abutment material, abutment type, and provisional restoration.

2.5 | Risk of bias analysis

Quality assessment was performed by both authors according to the Cochrane risk of bias tool (Higgins & Green, 2011) for included

randomized controlled trials (RCTs) and the Newcastle-Ottawa-Scale (NOS) (Wells et al., 2013) for included observational studies.

The Cochrane risk of bias tool is a domain-based evaluation, in which critical assessments are performed independently for each domain. These domains are "selection bias," "performance bias," "detection bias," "attrition bias," "reporting bias," and "other biases." The assigned judgment for each domain can be "high risk," "low risk," or "unclear risk" of bias.

The NOS is a quality assessment tool for nonrandomized trials, for their inclusion in a systematic review and meta-analysis. The quality of included studies was assessed according to three major domains: selection of the study groups, comparability of the study groups and ascertainment of either exposure or outcome of interest. Each domain can be awarded with a certain number of stars, resulting in a maximum number of nine stars. The final judgment of the included studies according to the NOS can be "Good," "Fair," or "Poor" quality.

2.6 | Statistical analysis

Means, standard errors and the 95%-confidence intervals of PROMs of study combinations were estimated by random-effects meta-regression for aggregate-level data. The same method was used to compare the mean outcome of groups of studies. The statistical analysis was performed using Stata 14.2 and significance level set at 0.05.

2.7 | Synthesis of results

Study data were extracted whenever the study met the inclusion criteria, and PROMs regarding aesthetic results assessed by VAS were reported. It was carefully controlled that data was only extracted, if 0 represented the worst treatment outcome (poor aesthetics) and 100 the best treatment outcome (perfect aesthetics) according to the VAS. PROMs were subdivided into two domains whenever possible: mucosa and FDP. Data were extracted separately for those two domains. When studies described more than one result for any of the two domains, only the most general one was extracted. For example, when a study reported both PROMs according to the general aesthetics of the restoration, and according to the color of the restoration, only data according to general aesthetics were extracted. Whenever PROMs were not reported according to VAS or a comparable rating system, studies were not included for data extraction.

The primary outcome of the meta-analysis was to compare the aesthetic results of implant- vs. tooth-supported fixed dental prostheses (FDPs) according to patients. Secondary outcomes were the influence of restoration material, implant type, and provisional phase on PROMs. As described above, additional data were acquired during the data extraction process; however, these data could not be analyzed due to reporting heterogeneity, incomplete data (pooled results), or missing data.

3 | RESULTS

Two systematic literature searches were performed. Part one represented studies reporting on patient-related outcomes regarding implant-supported FDPs. Through this search, 2,675 titles were retrieved (initial search) which were screened independently by two authors (SA, JW) to assess their suitability for inclusion (Figure 1). A consensus was obtained following discussion for the abstract search (329 abstracts). A total of 50 full-text articles were evaluated according to the inclusion and exclusion criteria. A total of 37 were found to qualify for inclusion in the data extraction, and finally, 16 studies including 19 relevant study cohorts were eligible for inclusion in the review (Figure 1).

The same systematic review process was performed for part two—patient-reported outcomes on tooth-supported FDPs (Figure 2). Here 5,915 titles were obtained from the initial search, the abstract search included 188 studies, and from these, 17 full-text articles were selected. Eight studies qualified for inclusion for data extraction. At the end, no study reporting on tooth-supported FDPs could be included. Therefore, it was not possible to perform a meta-analysis for the primary outcome, that is, the aesthetic outcome of tooth- vs. implant-supported FDPs according to PROMs. Nevertheless, sufficient data were available for implant-supported FDPs to perform meta-analyses for the secondary outcomes.

3.1 | Description of included studies

An overview of the excluded and included studies is given in Tables 3 and 4. Means and standard deviations of the outcome of the individual studies formed the basis for the statistical analysis. Results of the quality assessment are presented in Tables 5 and 6.

The study designs of the included studies were: two randomized clinical trials, eight prospective cohort studies, four retrospective and two cross-sectional studies (Table 7). Most studies were carried out in a university setting. In two studies reporting on implant-supported FDPs, multiple (a total of five) relevant study cohorts could be identified, the data of which were recorded separately. Various restorative materials (porcelain-fused-to-metal vs. all-ceramic),(Gallucci, Grütter, Nedir, Bischof, & Belser, 2011) and various implant designs (machined neck vs. rough neck vs. scalloped neck)(den Hartog et al., 2013) were examined in these cohorts.

A total of 816 implant-supported FDPs were evaluated by the patients by means of VAS. Of these FDPs 745 (91.3%) were single crowns, 12 (1.5%) were bridges and 2 studies pooled results from bridges and single crowns (n = 59 [7.2%]). The FDPs were supported by bone level or soft tissue level type implants, 48.4% and 39.5%, respectively. In 12.1%, the implant type was not reported (Table 7).

Only 20 FDPs were screw-retained (2.5%), 532 (65.2%) cement-retained, and in 6 studies, both retention types were used (23.7%). Porcelain-fused-to-metal (PFM) was used in 131 (16.1%), veneered zirconium dioxide in 232 (28.4%) and lithium disilicate in 24 FDPs (2.9%). In 212 restorations, the type of material was not reported (Table 7).

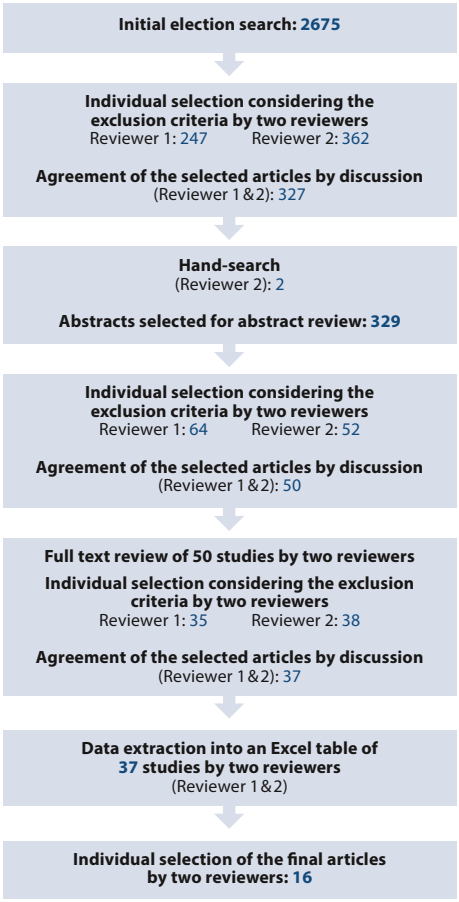

FIGURE 1 Flow diagram describing the search design implant supported group

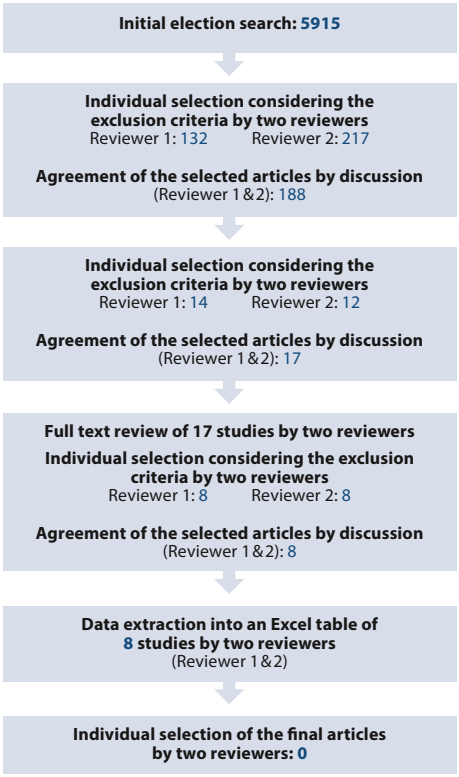

FIGURE 2 Flow diagram describing the search design tooth supported group

The implant abutments used in these included studies were predominantly made of titanium (*n* = 365 [44.7%]), titanium and zirconium dioxide (*n* = 133 [16.3%]), aluminum oxide (*n* = 10 [1.2%]), gold (*n* = 10 [1.2%]) and all-ceramic not further described (*n* = 67 [8.2%]). For 185 FDPs, the abutment material was not reported (Table 7).

In the cohorts included in this review, 385 (47.2%) FDPs were made with standardized abutments, 160 with customized abutments, both types were used in 86 restorations, and the abutment type was not reported in 185 FDPs (Table 7).

A total of 324 (39.7%) FDPs had a fixed provisional prior to insertion of the final crown or bridge and 200 (24.5%) did not. Implants documented in these studies were placed in the anterior and posterior region. In three cohorts (292 FDPs), it was not reported whether a provisional phase was performed within the prosthetic workflow (Table 7). Details on the individual VAS scores and the descriptive data are given in Table 7.

3.2 | Patient-reported VAS

3.2.1 | VAS mucosa score

Data extracted from 19 cohorts focusing on implant-supported FDPs showed that only 7 reported on the aesthetic outcome of the peri-implant soft tissue surrounding the reported FDP(s), as evaluated by the patients using VAS ratings. In 12 cohorts, this information was missing. The mean result of the "VAS mucosa score" was 84.7 (median: 86.7; min–max: 73.0–92.0) (unweighted data) (Table 8).

3.2.2 | VAS FDP score

A total of 16 studies (19 cohorts) reported on the patient evaluations focusing on the final aesthetic outcome of the implant-supported FDPs. The mean VAS was 88.9 (median: 90.3; min–max: 80.0–94.0; Table 8). The mean VAS values extracted by descriptive data are listed in detail in Table 7. For inclusion of the retrieved data into the statistical analysis (random-effects meta-analysis), only studies that reported the standard deviation of the VAS could be considered. Standard deviation of the VAS was reported only for few studies on implant-supported FDPs. An overview of the study cohorts, that were included into the meta-analysis is presented in Table 9. The VAS values of the individual study cohorts, their weight and their estimated treatment effect are given in Figures 3 and 4.

3.3 | Influence of restorative material/implant type/provisional phase on the outcome of VAS FDP

Only studies reporting the standard deviation could be considered for inclusion of the retrieved data into the statistical analysis (Table 10).

TABLE 3 Excluded studies during data extraction

Author (year)	Reason for exclusion
Implant supported (*n* = 21)	
Andersson, Bergenblock, Fürst and Jemt (2013)	Insufficient data
Andersson, Emami-Kristiansen and Högström (2003)	Follow-up <1 year
Avivi-Arber and Zarb (1997)	Insufficient data
Baracat, Teixeira, Dos Santos, de Da Cunha and Marchini (2011)	Insufficient data, no report on the amount or type of fixed reconstruction
Batisse, Bessadet, Decerle, Veyrune and Nicolas (2014)	Insufficient data
Bianchi and Sanfilippo (2004)	Insufficient data
Carollo (2003)	Insufficient data
Chang et al. (1999)	Repeated study
Gibbard and Zarb (2002)	Insufficient data
Kourkouta, Dedi, Paquette and Mol (2009)	Insufficient data
Meijndert et al. (2007)	Insufficient data
Moghadam et al. (2012)	No report on the amount or type of fixed reconstruction
Santing et al. (2013)	Not especially asked for aesthetic outcome
Schropp, Isidor, Kostopoulos and Wenzel (2004)	Insufficient data
Schropp and Isidor (2007)	Insufficient data
Sherif, Susarla, Hwang, Weber and Wright (2011)	Insufficient data
Tymstra et al. (2011)	Insufficient data
Tymstra, Meijer, Stellingsma, Raghoebar and Vissink (2010)	Insufficient data
Vanlıoğlu, Kahramanoğlu, Yıldız, Ozkan and Kulak-Özkan (2014)	PROMs not reported (email written to author-no response)
Vermylen, Collaert, Lindén, Björn and De Bruyn (1999)	Insufficient data
Vilhjálmsson, Klock, Størksen and Bårdsen (2011)	Insufficient data
Tooth supported (n = 8)	
Nicolaisen, Bahrami, Schropp and Isidor (2016)	Insufficient data
Ohlmann et al. (2014)	Insufficient data
Rimmer and Mellor (1996)	Insufficient data
Vanoorbeek, Vandamme, Lijnen and Naert (2010)	Insufficient data
Shi, Li, Ni and Zhu(2016)	Insufficient data
Alshiddi, BinSaleh and Alhawas (2015)	Insufficient data
Bömicke, Rammelsberg, Stober and Schmitter (2017)	Fully dentate patients
Nejatidanesh, Moradpoor and Savabi (2016)	Fully dentate patients

In implant-supported FDPs, mean patient ratings varied between 93.3 (95% CI = 78.8–100) (veneered zirconium dioxide) and 85.2 (95% CI = 70.5–99.9) (PFM + gold). The differences according to the applied restorative materials were not statistically significant ($p = 0.616$) (Table 10). Patients reported slightly higher VAS ratings in FDPs supported by tissue level type implants (mean = 92.5; 95% CI = 88.8–96.2) compared to bone level type implants (mean = 89.2; 95% CI = 86.1–92.4). However, the difference was not statistically significant ($p = 0.128$) (Table 10). Presence of a provisional phase did not improve the aesthetic outcome according to patients' VAS ratings (90.3 vs. 90.0; $p = 0.909$; Table 10).

4 | DISCUSSION

Within the limitations of this systematic review, patients' satisfaction was high for implant- supported FDPs and the surrounding mucosa.

No influence on the PROMs results was identified among the used dental materials for FDPs, the presence of a provisional phase within the implant-prosthetic workflow or the type of dental implant used.

The primary goal of any prosthodontic procedure is to satisfy the patient receiving a dental treatment. Although the assessment of the patient is subjective and difficult to quantify, it has gained interest in recent years, a fact also observed in clinical studies. De Bruyn stated in his systematic review about the current use of patient-centered/

TABLE 4 Included studies/cohorts (*n* = 19 cohorts, *n* = 16 studies)

Author (year)	Total *N* of FDPs	Total *N* of patients	mean follow-up (years)	Outcome Mucosa	Outcome FDP	*SD* FDP
Implant supported (*n* = 19)						
Bonde, Stokholm, Schou and Isidor (2013)	46	42	10.0	82.0	91.0	15.0
Boronat-Lopez, Carrillo, Peñarrocha and Peñarrocha-Diago (2009)	12	12	1.0	NA	83.0	
Chang et al. (1999)	21	20	3.0	NA	94.0	7.0
Chang and Wennström (2013)	32	32	7.5	NA	91.8	14.8
Cosyn et al. (2012)	46	44	2.5	92.0	94.0	6.0
Covani, Canullo, Toti, Alfonsi and Barone (2014)	47	47	5.0	73.0	80.5	11.3
De Rouck, Collys and Cosyn (2008)	30	30	1.0	NA	93.0	
den Hartog et al. (2013) (1)	31	31	1.5	86.7	88.0	11.0
den Hartog et al. (2013) (2)	31	31	1.5	87.1	89.0	10.0
den Hartog et al. (2013) (3)	31	31	1.5	83.9	91.0	8.0
Ekfeldt, Fürst and Carlsson (2011)	40	25	3.0	NA	90.0	
Gallucci et al. (2011) (1)	10	10	2.0	NA	91.8	5.9
Gallucci et al. (2011) (2)	10	10	2.0	NA	91.8	10.0
Hartlev et al. (2014)	54	54	2.8	88.0	83.0	
Hof et al. (2014)	60	60	4.1	NA	80.0	
Kolinski et al. (2014)	59	37	3.0	NA	89.2	9.4
Spies, Patzelt, Vach and Kohal (2016)	24	24	2.6	NA	90.3	13.0
Tey, Phillips and Tan (2016)	NA	206	5.2	NA	85.2	14.5
Nejatidanesh et al. (2016)	232	121	5.9	NA	93.3	5.2
Total (*n* = 19)	816	867	4.3	-	-	-

Note. [a]Number of ratings.

TABLE 5 Quality assessment of included studies according to NOS

Author (year)	Selection	Comparibility	Outcome	Quality
Bonde et al. (2013)	4	2	2	Good
Boronat-Lopez et al. (2009)	3	1	1	Fair
Chang et al. (1999)	4	2	3	Good
Chang and Wennström (2013)	4	1	3	Good
Cosyn et al. (2012)	4	2	2	Good
Covani et al. (2014)	4	2	3	Good
De Rouck et al. (2008)	4	1	2	Good
Ekfeldt et al. (2011)	4	1	3	Good
Hartlev et al. (2014)	4	2	1	Fair
Hof et al. (2014)	4	1	3	Good
Kolinski et al. (2014)	4	1	1	Fair
Spies et al. (2016)	4	1	1	Fair
Tey et al. (2016)	4	1	2	Good
Nejatidanesh et al. (2016)	4	1	3	Good

TABLE 6 Quality assessment for included randomized clinical trials, according to Cochrane risk of bias tool

Author (year)	Random sequence	Allocation concealment	Blinding	Blinding (outcome)	Outcome data	Selective reporting	Other biases
den Hartog et al. (2013)	+	+	0	+	+	+	+
Gallucci et al. (2011)	+	+	+	+	+	+	+

reported outcomes that half of the relevant literature (300 of 635) were studies published in the last 6 years. His study, therefore, concluded a growing interest in PROMs by the scientific community (De Bruyn et al., 2015).

Various terminology has been used in scientific studies, such as patient satisfaction, patient-centered outcomes, patient-reported outcomes, and patient-reported outcome measures (Cosyn et al., 2017; Lang et al., 2012; McGrath et al., 2012).

Patients' expectations are increasing and with respect to rehabilitation with fixed implant- or tooth-supported FDPs, treatments result in proportionally higher costs compared to removable prostheses. In the era of modern implantology, many surgical and prosthetic workflows are possible today with the goal of achieving the best possible aesthetic outcome. These advances substantially increase costs, resulting in even more critical patients from an aesthetic point of view (Cosyn et al., 2017). However, it has been shown that patients are less critical than clinicians when judging aesthetics (Cosyn, Eghbali, De Bruyn, Dierens, & De Rouck, 2012; Cosyn et al., 2013; Hartlev et al., 2014; Meijndert et al., 2007). In an early study by Chang et al., 1999; a total of 41 implant-supported crowns were evaluated by patients and prosthodontists (Chang et al., 1999). Patients were highly satisfied with their implant-supported crowns with mean VAS values of 100; however, the assessment by prosthodontists revealed a significantly lower degree of satisfaction. This finding was confirmed in a study from Tettamanti et al., 2016; in which patients assessed their reconstruction with respect to pink aesthetics, white aesthetics, and overall aesthetics using visual analogue scales. The same procedure was performed using a new "peri-implant and crown index (PICI)." Orthodontists, Prosthodontists, general dentists, and lay people evaluated pink and white characteristics using visual analogue scales (100 mm length) in comparison with the contralateral tooth. The patients were asked the same questions; a comparison of the patient-related outcomes and PICI was obtained. The overall aesthetic assessments of patients were 94.17%, followed by prosthodontists 68.57%, lay people (66.69%) and general dentists (65.22%), with orthodontists being the most critical (57.16%; Tettamanti et al., 2016).

In this systematic review, the patient-reported outcome of 816 FDPs evaluated by patients in the implant-supported group revealed a mean VAS value of 90 (Table 7).

Dueled, Gotfredsen, Trab Damsgaard, & Hede, 2009 performed a clinical study reporting on 129 patients with tooth agenesis rehabilitated with implant or tooth-supported FDPs. Improved aesthetic outcomes were obtained for the implant-supported group and a positive but not significant correlation was observed between the professional and patient perception of the aesthetic outcome (Dueled et al., 2009). The patients were more satisfied with the overall outcome than the professional clinician (Dueled et al., 2009).

4.1 | Influence of restoration material

In a prospective study with a 3-year follow-up, implants were restored either with all- ceramic or metal-ceramic crowns (Hosseini,

TABLE 7 Characteristics of study cohorts related to implant-supported FDPs and patient-reported outcomes (PROMS) (n = 19 cohorts, n = 16 studies)

	No. of studies (%)	Total *N* of reconstruction (%)	Total *N* of patients (%)	Outcome mean	Outcome min-max	PROMS mean unweighted	PROMS mean weighted
All study cohorts	19 (100)	816 (100)	867 (100)	88.9	80.0–94.0	88.9	88.0
Studydesign							
RCT	5 (26.3)	113 (13.8)	113 (13.0)	90.3	88.0–91.8	90.3	89.8
Prospective	8 (42.1)	293 (35.9)	266 (30.7)	88.0	80.5–94.0	88.0	87.3
Retrospective	4 (21.1)	332 (40.7)	412 (47.5)	87.1	80.0–93.3	87.1	87.1
Cross-sectional	2 (10.5)	78 (9.6)	76 (8.8)	92.9	91.8–94.0	92.9	93.1
Setting							
Private practice	3 (15.8)	286 (35.0)	381 (43.9)	87.2	83.0–93.3	87.2	87.5
University	13 (68.4)	410 (50.2)	404 (46.6)	88.9	80.0–94.0	88.9	88.1
Multicenter	1 (5.3)	59 (7.2)	37 (4.3)	89.2	-	89.2	89.2
Specialist clinic	2 (10.5)	61 (7.5)	45 (5.2)	92.0	90.0–94.0	92.0	91.8
Type of Implant							
Bone Level Implant	11 (57.9)	395 (48.4)	390 (45.0)	87.7	80.0–94.0	87.7	86.7
Soft Tissue Level Implant	5 (26.3)	322 (39.5)	209 (24.1)	92.2	90.3–94.0	92.2	93.0
NA	3 (15.8)	99 (12.1)	268 (30.9)	88.1	85.2–90.0	88.1	86.2
Brand							
Straumann	3 (15.8)	252 (30.9)	141 (16.3)	92.3	91.8–93.3	92.3	93.1
Nobel	9 (47.4)	350 (42.9)	343 (39.6)	89.2	80.0–94.0	89.2	88.1
Astra	1 (5.3)	32 (3.9)	32 (3.7)	91.8	–	91.8	91.8
Defcon Avantblast TSA	1 (5.3)	12 (1.5)	12 (1.4)	83.0	–	83.0	83.0
Sweden Martina	1 (5.3)	47 (5.8)	47 (5.4)	80.5	–	80.5	80.5
Ziraldent	1 (5.3)	24 (2.9)	24 (2.8)	90.3	–	90.3	90.3
Straumann, Nobel, Biomet 3i	1 (5.3)	0 (0.0)	206 (23.8)	85.2	–	85.2	85.2
NA	2 (10.5)	99 (12.1)	62 (7.2)	89.6	89.2–90.0	89.6	89.5
Screw/cement retention							
Screw	2 (10.5)	20 (2.5)	20 (2.3)	91.8	91.8–91.8	91.8	91.8
Cement	9 (47.4)	532 (65.2)	414 (47.8)	90.1	80.5–94.0	90.1	90.1
Both	6 (31.6)	193 (23.7)	384 (44.3)	87.2	80.0–91.0	87.2	85.7
NA	2 (10.5)	71 (8.7)	49 (5.7)	86.1	83.0–89.2	86.1	87.7
Type of reconstruction							

(Continues)

TABLE 7 (continued)

	No. of studies (%)	Total *N* of reconstruction (%)	Total *N* of patients (%)	Outcome mean	Outcome min-max	PROMS mean unweighted	PROMS mean weighted
SC	16 (84.2)	745 (91.3)	612 (70.6)	89.5	80.0–94.0	89.5	89.0
FPD	1 (5.3)	12 (1.5)	12 (1.4)	83.0	–	83.0	83.0
Both	2 (10.5)	59 (7.2)	243 (28.0)	87.2	85.2–89.2	87.2	85.8
Restoration material							
PFM	5 (26.3)	131 (16.1)	131 (15.1)	88.0	80.5–93.0	88.0	87.2
PFM+all-ceramic	2 (10.5)	100 (12.3)	98 (11.3)	88.5	83.0–94.0	88.5	87.9
PFM+Gold	1 (5.3)	–	206 (23.8)	85.2	–	85.2	85.2
All-ceramic+acrylic	4 (21.1)	117 (14.3)	97 (11.2)	91.7	90.0–94.0	91.7	91.4
Veneered Zirconia and monolithic Zirconia	1 (5.3)	232 (28.4)	121 (14.0)	93.3	–	93.3	93.3
Lithium disilicate (emax)	1 (5.3)	24 (2.9)	24 (2.8)	90.3	–	90.3	90.3
NA	5 (26.3)	212 (26.0)	190 (21.9)	87.4	80.0–91.0	87.4	86.4
Abutment							
Standardized/prefabricated	6 (31.6)	385 (47.2)	269 (31.0)	92.2	90.3–94.0	92.2	92.5
Individualized	6 (31.6)	160 (19.6)	160 (18.5)	88.7	80.5–91.8	88.7	87.0
Both	2 (10.5)	86 (10.5)	69 (8.0)	92.0	90.0–94.0	92.0	92.6
NA	5 (26.3)	185 (22.7)	369 (42.6)	84.1	80.0–89.2	84.1	84.4
Abutment material							
Titanium	5 (26.3)	365 (44.7)	254 (29.3)	89.8	80.5–93.3	89.8	90.4
Titanium + Zirconium dioxide	4 (21.1)	133 (16.3)	118 (13.6)	89.5	88.0–91.0	89.5	89.5
Titanium + ceramic	1 (5.3)	46 (5.6)	44 (5.1)	94.0	–	94.0	94.0
Gold	1 (5.3)	10 (1.2)	10 (1.2)	91.8	–	91.8	91.8
Aluminum oxide	1 (5.3)	10 (1.2)	10 (1.2)	91.8	–	91.8	91.8
ceramic—no further spec	2 (10.5)	67 (8.2)	62 (7.2)	92.5	91.0–94.0	92.5	92.0
NA	5 (26.3)	185 (22.7)	369 (42.6)	84.1	80.0–89.2	84.1	84.4
Provisional Phase loaded on implants							
Yes	11 (57.9)	324 (39.7)	302 (34.8)	89.3	83.0-93.0	89.3	88.8
No	5 (26.3)	200 (24.5)	178 (20.5)	89.9	80.5–94.0	89.9	89.2
NA	3 (15.8)	292 (35.8)	387 (44.6)	86.2	80.0–93.3	86.2	86.9

TABLE 8 No. of reconstructions, patients, mean follow-up, patient-reported outcome, studies on implant-supported FDPs (*n* = 19 cohorts, *n* = 16 studies)

	Data reported in *n* cohorts	Data missing	Mean	*SD*	Median	Min-max
N of reconstructions	19	0	45.3	49.1	31.5	10–232
Actual *N* of pts	19	0	45.6	46.0	31.0	10–206
Mean follow-up (years)	19	0	3.4	2.4	2.8	1.0–10.0
VAS mucosa	7	12	84.7	6.0	86.7	73.0–92.0
VAS crown/bridge	19	0	88.9	4.5	90.3	80.0–94.0

TABLE 9 Patient-reported outcomes for cohorts of implant FDPs including standard deviation (*SD*)—*n* = 14

	Total *N* of pats. (%)	mean VAS crown/bridge	*SD*	95%-CI
Bonde et al. (2013)	42 (6.1)	91	15	86.3–95.7
Chang et al. (1999)	20 (2.9)	94	7	90.7–97.3
Chang and Wennström(2013)	32 (4.7)	91.8	14.8	86.5–97.1
Cosyn et al. (2012)	44 (6.4)	94	6	92.2–95.8
Covani et al. (2014)	47 (6.9)	80.5	11.3	77.2–83.8
den Hartog et al. (2013) (1)	31 (4.5)	88	11	84–92
den Hartog et al. (2013) (2)	31 (4.5)	89	10	85.3–92.7
den Hartog et al. (2013) (3)	31 (4.5)	91	8	88.1–93.9
Gallucci et al. (2011) (1)	10 (1.5)	91.81	5.94	87.6–96.1
Gallucci et al. (2011) (2)	10 (1.5)	91.8	10.04	84.6–99
Kolinski et al. (2014)	37 (5.4)	89.2	9.4	86.1–92.3
Spies et al. (2016)	24 (3.5)	90.3	13	84.8–95.8
Tey et al. (2016)	206 (30.0)	85.2	14.5	83.2–87.2
Nejatidanesh et al. (2016)	121 (17.6)	93.3	5.2	92.4–94.2
Total[a]	686 (100)	90.0	1.00[b]	87.9–92.2

Notes. [a]Estimation by random-effects meta-regression. [b]Estimated standard error.

Worsaae, Schiodt, & Gotfredsen, 2013). Patient-reported outcomes and aesthetic evaluations by clinicians were assessed and no correlation could be identified between the professional and patient-reported aesthetic outcome. Patient`s evaluations regarding the aesthetic outcome showed no statistically difference of all-ceramic and metal- ceramic restorations (Hosseini et al., 2013). In the present review, the same findings were obtained. VAS ratings of the patients showed no influence of the material choice of the reconstructions.

4.2 | Influence of implant type

Implants featuring the abutment connection at the crestal bone level to replace single edentulous spaces are preferably indicated in the aesthetic zone. With a bone level implant design, the clinician has more prosthetic freedom to determine the location of the final mucosal zenith position and to individualize the emergence profile and, therefore, the peri-implant mucosa. Clinical studies have presented acceptable aesthetic outcomes (Buser et al., 2011, 2013; Santing, Raghoebar, Vissink, den Hartog, & Meijer, 2013; Wittneben et al., 2017). Consequently, an enhancement of the overall aesthetic outcome would be hypothesized. However, in this review, the patient-reported outcomes regarding VAS FDP scores were higher for patients with soft tissue level implants compared to those with bone level type implants however this was not statistically significant (Table 7).

4.3 | Influence of provisional phase implementation

The implementation of a distinct provisional phase is a commonly used treatment concept for implants placed in the aesthetic zone (Cho, Shetty, Froum, Elian, & Tarnow, 2007; Furze, Byrne, Alam, & Wittneben, 2016; Parpaiola, Sbricoli, Guazzo, Bressan, & Lops, 2013; Priest, 2005; Wittneben, Buser, Belser, & Brägger, 2013). The aim of a provisional phase is to condition and shape the peri-implant soft tissue, including the individualization of the mucosa and emergence profile, the papillae, the cervical soft tissue margin, and the finalization of the position of the gingival zenith. A randomized clinical trial by Furze et al. showed that this provisional phase with soft tissue conditioning does improve the final aesthetic result (Furze et al., 2016). 20 patients

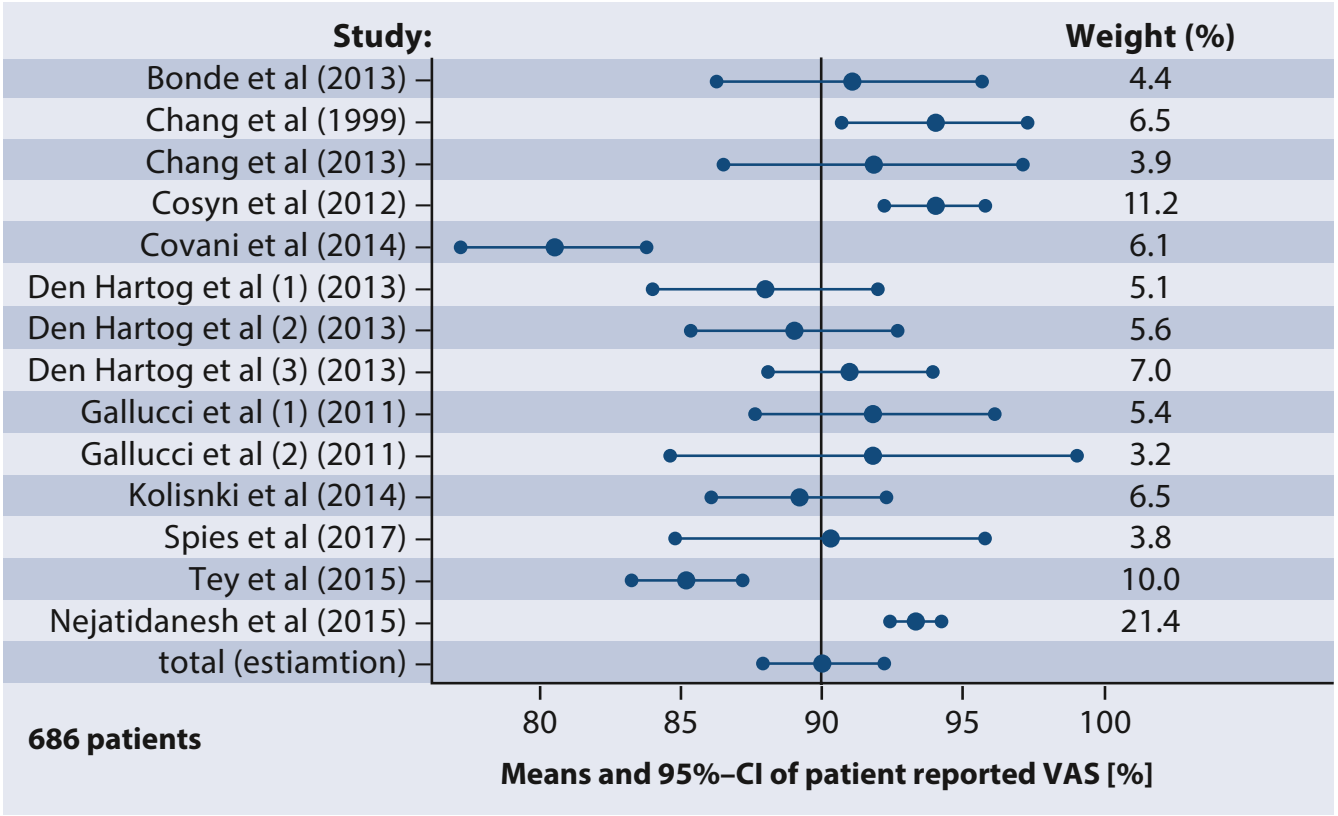

FIGURE 3 Patient-reported outcomes, implant supported group (only data with standard deviation)

received bone level implants in the aesthetic zone and after reopening, using a randomization process to assign each to either cohort group 1 (provisional phase present) or cohort group 2 (without provisional phase). Implants were finally restored with an all-ceramic crown. The mean values of combined modPES and WES were 16.7 for group 1 and 10.5 for Group 2, which concluded a statistically significant difference.

In the present study, there was no statistically significant difference with the use of provisional restorations on implant-supported FDPs according to PROMs. From the limited available data, implant-supported provisional restorations were located in both- posterior and anterior sites and therefore a conclusion cannot be stated focusing on aesthetic sites.

4.4 | Limitations of the study

In general, systematic reviews lack in homogeneity among materials used for FDPs across clinical studies, regardless of the type of support. Unfortunately, in the present review, no studies could be identified to be included focusing on tooth-supported FDP in partially edentulous patients.

The perception of a patient might be influenced by their expectations and experience but represents the value of a reconstruction evaluated by the patient him- or herself.

Aesthetics is an important PROM and, therefore, it is commonly included in clinical studies. However, the limitation of the information given by the patients is that non-standardized questions are frequently used with varying scoring methods. This lack of standardization method in the assessment of PROMs (McGrath et al., 2012) was the reason why only studies using VAS ratings were included here. Another limitation in performing the assessment is the validity and reliability of the "ad-hoc" approach.(Cosyn et al., 2017) For the use of future investigations, standardized questions related to the final aesthetic outcome should be used and patient responses collected without the clinician performing the treatment being present to minimize influencing factors.

5 | CONCLUSION

Within the limitations of this systematic review, it can be concluded that:

- The aesthetics of implant-supported FDPs are highly rated by patients (VAS = 90.0; 87.9–92.2).
- No studies were found that reported on PROMS focusing on tooth-supported FDPs in partially edentulous patients.
- The appearance of the mucosa surrounding the implant-supported FDPs was highly rated (VAS = 84.7; min. 73.0–max. 92.0) by PROMs.
- Implant neck design, that is, tissue or bone level has no influence on aesthetic ratings by the patients: 92.5 vs. 89.2.
- PROMs ratings were higher with patients having soft tissue level implants compared to the ones with bone level type implants however without being statistically significant ($p = 0.128$).

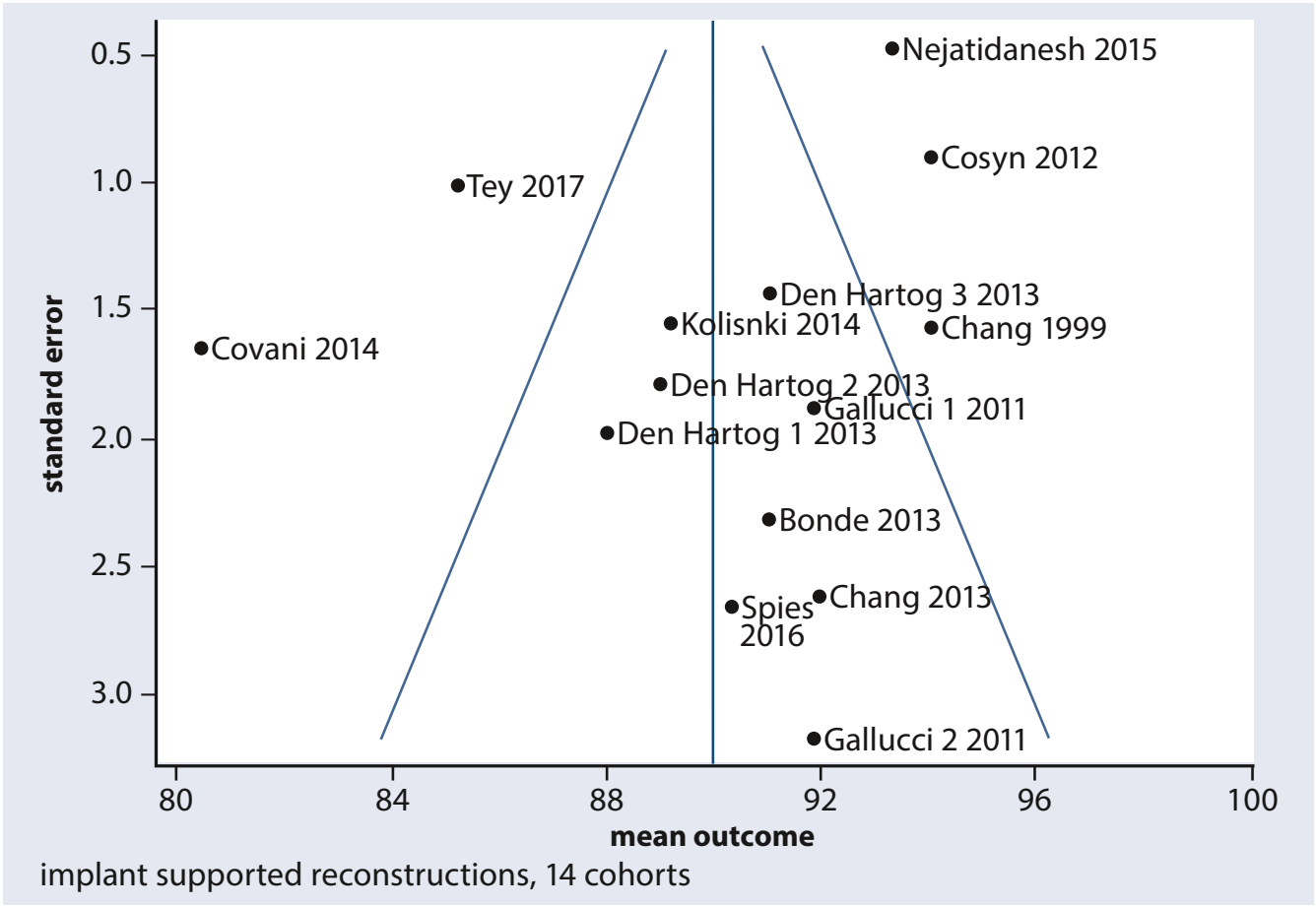

FIGURE 4 Funnel plot of included study cohorts, reporting on implant-supported reconstructions (*n* = 14)

TABLE 10 Patient-reported outcomes—implant-supported study cohorts—comparison of groups (estimation by random-effects meta-regression)

	Studies	Patients	Mean VAS	Standard error	95%-CI	*p*-value
Restoration material						
PFM	3	89	87.8	2.87	78.7–96.9	0.616
All-ceramic	3	72	92.4	2.95	83.0–100	
Veneered Zirconiumdioxide	1	121	93.3	4.54	78.8–100	
Lithiumdisilicate (emax)	1	24	90.3	5.24	73.6–100	
PFM + ceramic	1	44	94.0	4.61	79.3–100	
PFM + gold	1	206	85.2	4.63	70.5–99.9	
Implant type						
Bone level implant	7	234	89.2	1.39	86.1–92.4	0.128
Soft tissue level implant	5	209	92.5	1.63	88.8–96.2	
Provisional phase						
Yes	8	206	90.3	1.46	87.0–93.6	0.909
No	4	153	90.0	1.95	85.6–94.4	

- Individual restorative materials had no influence on ratings of PROMS focusing on the aesthetics of implant-supported FDPs.
- The use of a provisional restoration had no effect on aesthetic ratings of the definitive restorations on implant-supported FDPs evaluated by PROMs.

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SUPPORTING INFORMATION

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

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