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REVIEW ARTICLE

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Treatment effect of implant-supported fixed complete dentures and implant overdentures on patient-reported outcomes: A systematic review and meta-analysis

Samir Abou-Ayash[1] | Manrique Fonseca[1] | Stefano Pieralli[2] | Daniel R. Reissmann[3]

[1]Department of Reconstructive Dentistry and Gerodontology, University of Bern, Bern, Switzerland

[2]Department of Prosthodontics, Geriatric Dentistry and Craniomandibular Disorders, Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Berlin, Germany

[3]Department of Prosthetic Dentistry, Center for Dental and Oral Medicine, University Medical Center Freiburg, Freiburg im Breisgau, Germany

Correspondence
Samir Abou-Ayash, Department of Reconstructive Dentistry and Gerodontology, zmk Bern, Freiburgstrasse 7, Bern 3010, Germany.
Email: samir.abou-ayash@unibe.ch

Abstract

Objectives: To analyze the effect of implant treatment in edentulous patients rehabilitated with implant-supported fixed complete dentures (IFCDs) or implant overdentures (IODs) on dental patient-reported outcomes (dPROs).

Materials and Methods: In January 2022, Medline, Embase, CINAHL, Cochrane Library, PubMed Central, Web of Science, and ClinicalTrials.gov were screened for prospective clinical studies on completely edentulous patients treated with IFCDs and/or IODs, reporting pre-treatment and follow-up dPROs. Hedges' g effect sizes (ES) with corresponding 95% confidence intervals (CI) were calculated. Afterward, meta-analyses were conducted using random effect models.

Results: A total number of 1608 records was initially identified. Of those, 28 studies reporting dPROs from 1457 patients were finally included. The applied dental patient-reported outcome measures (dPROMs) included several versions of the Oral Health Impact Profile (OHIP) or specific items assessing satisfaction with Visual Analogue Scales (VAS). The overall ES was large for rehabilitation with IFCDs (1.68 [CI: 1.15, 2.20]) and IODs (1.26 [CI: 0.99, 1.52]) with no significant difference ($p = .165$) between the two. Denture stability was the only factor rated significantly higher for IFCDs (ES difference: 2.37 [CI: 0.21, 4.54]; $p = .032$). Subgroup analyses revealed moderately higher ES for IODs on two implants relative to one implant (ES difference: 0.73 [CI: 0.34, 1.12]; $p < .001$).

Conclusions: There is a strong positive effect of implant treatment in edentulous patients, independent of the type of prosthetic rehabilitation. In patients seeking high stability, IFCDs may be preferable. In mandibular IODs on a single implant, there was a significantly positive effect of an additional implant on dPROs.

KEYWORDS
complete denture, edentulous, meta-analysis, patient-reported outcome measures, patient-reported outcomes, PROMs, PROs, systematic review

1 | INTRODUCTION

Despite a decreasing prevalence of edentulism—expected to continue—over the past several decades in many countries, many individuals worldwide have still lost all teeth in at least one jaw (Peres et al., 2019). In 2015, an estimated 4.1% of the world's population was reported to be edentulous (Kassebaum et al., 2017). Furthermore, another recent study in older adults (65–74 years) in Germany showed a prevalence of edentulism of 12.4% (Schwendicke et al., 2020). This highlights the fact that edentulism remains an important public health concern especially in older adults, with a potentially great impact on patients' daily life (Polzer et al., 2010; Rodrigues et al., 2012). Obviously, without teeth the masticatory function is compromised. Furthermore, a reduction of the perceived esthetics and, subsequently, patient self-esteem and social life can be expected. Such compromises are highly relevant to patients, and therefore negatively affect their oral health-related quality of life (OHRQoL). (John, 2018; Reissmann, 2019). Since edentulism affects the entire oral cavity and masticatory system, it is not surprising that edentulism affects all four dimensions of OHRQoL, namely *Oral Function*, *Orofacial Esthetics*, *Orofacial Pain*, and *Psychosocial Impact* (John et al., 2014, 2016). However, it is not only the direct impact of tooth loss on the patient perceptions: Edentulism also appears to be related to general health conditions such as dementia, mainly due to its impact on diet as a result of reduced masticatory function (Emami et al., 2013; Joshipura et al., 1996).

Edentulous patients can be rehabilitated with complete dentures, but this is frequently associated with various problems, mainly related to low denture stability. One solution to alleviate the shortcomings of complete dentures, such as low masticatory performance, and to substantially increase dPROs, is the provision of dental implants to either support or retain an implant-removable overdenture (IOD) or an implant-fixed complete denture (IFCD; Reissmann et al., 2017; Schierz & Reissmann, 2021). The type of prosthodontic reconstruction to be provided determines the number of implants. For IFCDs, a minimum of four implants are required in both the maxilla and the mandible according to modern implant concepts (Soto-Peñaloza et al., 2017). In contrast, a single implant in the midline of the edentulous mandible can be used for an IOD; this also results in increased dPROs relative to conventional complete dentures (Cordioli et al., 1997; Schwindling et al., 2018). However, current guidelines recommend at least two implants to retain an IOD in the mandible (Feine et al., 2002). Various attachment types can be selected for IODs, ranging from single attachments (e.g., balls) to bars for primary splinting of the implants (Al-Zubeidi et al., 2012; Bressan et al., 2012; Messias et al., 2021).

The most important decision for a patient when choosing an implant-supported denture is whether the denture should be fixed or removable. Obviously, an IFCD produces the sensation of having physiological dentition. In contrast, an IOD must be removed for cleaning and might suggest the perception of being old and not as vital as in the past. However, with an IFCD, not all lost hard and soft tissue can be replaced without preventing access to the implant and surrounding soft tissue. Given these considerations, it is not surprising that the evidence is still inconclusive whether IFCDs or IODs are preferable for patients in terms of dPROs, and which factors affect the outcomes. Therefore, the present study was designed to evaluate and compare the treatment effects of IFCDs and IODs on pre- and post-treatment dPROs and to identify potential influencing factors.

2 | MATERIALS AND METHODS

2.1 | Study protocol

The study protocol was registered in the international prospective register of systematic reviews (PROSPERO; registration number: CRD42022269277, Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022269277), and followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher, et al., 2009). No ethical approval was required because the present study is a systematic review. The research question was based on the P.I.C.O model as follows:

Population: Fully edentulous patients.
Intervention: Rehabilitation with implant-supported fixed complete dentures (IFCDs).
Comparison: Rehabilitation with implant overdentures (IODs).
Outcome: Patient-reported outcomes, including pre- and post-treatment evaluations.

The resulting P.I.C.O. question was: 'In edentulous patients, what is the effect on patient-reported outcomes of implant treatments using IFCDs relative to IODs?' Furthermore, the effects of attachment type, follow-up time, and implant number per reconstruction were to be evaluated.

2.2 | Search strategy

Systematic literature searches were adapted to multiple electronic databases and executed by an information specialist in medicine (H.J.) to identify potentially relevant documents:

- Medline (Ovid) (incl. Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Medline Daily and Ovid Medline Versions) (1946 – January 11, 2022).
- Embase (Ovid) (1974 – January 11, 2022).
- CINAHL (EBSCOhost) (1937 – January 11, 2022).
- Cochrane Library (Wiley) (1996 – January 11, 2022).
- PubMed Central (1946 – January 11, 2022).
- Web of Science (all editions) (1900 – January 11, 2022).
- ClinicalTrials.gov (NLM).

Candidate search terms were selected based on subject headings, titles, abstracts, and author keywords from a list of core references

of a previous systematic review (Yao et al., 2018). Thereafter, a draft search strategy was developed, adding further relevant vocabulary from various database thesauri. Search terms were also identified using the Yale MeSH Analyzer and the word frequency analysis tool of the PubReMiner. The initial search strategy in Medline (Ovid) was tested against a list of core references from the aforementioned review (Yao et al., 2018) to see whether they were included in the search results. After refinement and consultations with the research team of this systematic review, search strategies were created for each information source as a combination of database-specific controlled vocabulary (subject headings) and textwords. Synonyms and similar terms were included in the textword search. Animal studies were formally excluded from the search results. No limits were applied in the database searches considering study types, languages, publication years, or other criteria. The full search strategies are presented in the Appendix S1. Duplicate references were removed using EndNote's (EndNote; Thomson Reuters) duplicate identification strategy, followed by manual curation.

2.3 | Eligibility criteria

Inclusion and exclusion criteria were as follows:

2.3.1 | Inclusion

- Prospective clinical investigations.
- Reports of dPROs prior to implant placement and after prosthetic rehabilitation using validated dPROMs.
- Completely edentulous participants.
- Treatment with IOD or IFCD in at least one jaw.
- Minimum sample size per relevant study arm or cohort ≥10 patients.
- Mean follow-up period ≥1 year from delivery of the final restoration-supported or -retained reconstruction.
- Articles written in English.

2.3.2 | Exclusion

- In vitro or animal studies, retrospective clinical investigations, unpublished data, conference abstracts.
- Partially dentate participants, or unclear dental status.
- Insufficient documentation regarding dPROs or dPROMs.
- Non-validated or self-designed dPROMs.
- Use of categorical scales /questionnaires (e.g., yes/no responses).

2.4 | Data selection and extraction process

After automatic elimination of duplicates, the search results were imported into a software application (Rayyan; available at: www.rayyan.ai) dedicated to literature screening in systematic reviews, and two reviewers (M.F. & S.P.) performed, independently, the data screening based on the eligibility criteria. Included articles were screened based on their title, followed by the abstract, and, when meeting the inclusion criteria, the full text. After each step, the reviewers compared the in- and excluded studies and a Cohen's kappa score was calculated to assess the degree of agreement. In case of disagreement, a third reviewer (S.A.-A.) was consulted.

Data extraction from the included studies was performed by each reviewer individually. For this purpose, a data extraction sheet was designed. If multiple dPROMs were used in one study, data from all dPROMs were extracted separately. When dPROs from the same cohort were reported at multiple follow-up time points within a study or in consecutive studies, only the data from the longest follow-up period was extracted. If multiple items with VAS were used, only the data from the most frequently used items were extracted. After screening all articles, the most frequently evaluated items included the overall evaluation of the treatment, comfort, stability, chewing, speaking, esthetics, pain, and cleaning. For VAS, it was ensured that 0 represents the worst possible outcome (e.g., lowest satisfaction or lowest comfort). If this was not the case, the scales were transposed accordingly for comparison. For the different versions of the OHIP questionnaire, only the OHIP summary scores were extracted since reporting of the domain scores was inconsistent over the studies. If data could not be extracted, studies were excluded from further evaluation, and the reason for exclusion was noted. In case of doubt, the corresponding authors of the articles of interest were contacted to obtain additional information ($n = 17$; Appendix S2).

The risk of bias of the included studies was assessed, independently, by M.F. and S.P. using the Cochrane Risk of Bias tool (RoB 2.0) for randomized trials (Higgins et al., 2011) and the Risk of Bias in Non-Randomized Studies tool (ROBINS-I) in the case of non-randomized trials (Sterne et al., 2016). A third reviewer (S. A.-A.) was consulted in case of disagreement. The risk of bias visualization tool (ROBVIS) was used for graphical representation of the results. Evaluating the certainty of the evidence of included studies, the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system was used (Mustafa et al., 2013). Accordingly, the certainty of each meta-analysis was rated as high, moderate, low, or very low.

2.5 | Statistical analysis

Data from studies were only included in the meta-analyses if either (1) mean and standard deviation (SD) could be obtained directly from the studies, (2) mean could be obtained directly from the study and standard deviation could be calculated from the 95% confidence interval of the mean, or (3) mean and standard deviation could be estimated from the median and interquartile range (Wan et al., 2014). Based on baseline and follow-up data, Hedges' g effect sizes (ES) were subsequently calculated for each dPROM (Goulet-Pelletier & Cousineau, 2018). Since cross-measurement correlations between

study baseline and follow-up data were not known for all studies and the number of patients at follow-up and baseline was not identical for all studies, Hedges' *g* was calculated assuming independent data. ES values of 0.20, 0.50, and 0.80 Hedges' *g* are commonly considered to be indicative for small, medium, and large effects, respectively (Cohen, 1992). Random effects models (REMLs) were used to estimate overall ES with a 95% confidence interval (CI). ES of subgroups were compared using a random-effects (more than one study in at least one of the subgroups) or fixed-effects (one study per subgroup) meta-regression. Any potential bias of including all studies regardless of unequal or equal number of patients at baseline and follow-up was ascertained by comparing the ES of the OHIP data of studies with unequal ($n=12$) and equal ($n=7$) patient counts at baseline and follow-up. The estimated difference (equal vs. unequal) in ES was 0.27 (CI: −0.12, 0.66; $p=.179$), indicating no substantial or statistically significant difference between the two types of analysis.

3 | RESULTS

Initially, 1608 records were identified during the systematic literature search, of which 1019 remained for title screening after duplicate elimination. After a consensus was reached for the title screening, 599 abstracts were screened. After further consensus, 191 full-texts were analyzed, of which 59 were included for data extraction (Figure 1). The kappa scores were 0.78 for the title screening, 0.86 for the abstract screening, and 0.91 for the full-text screening. Data could finally be extracted from 28 studies. The reasons for study exclusion at the data-extraction stage are provided in Appendix S3.

3.1 | Description of included studies

Among the 28 included studies were 15 RCTs (Abou-Ayash et al., 2020; Al-Zubeidi et al., 2012; Bryant et al., 2015; De Kok et al., 2011; de Resende et al., 2021; De Souza et al., 2015; Gaballa et al., 2021; Hartmann, Bandeira, et al., 2020; MacEntee et al., 2005; Meijer et al., 2003; Michaud et al., 2012; Montero et al., 2021; Park et al., 2019; Raghoebar et al., 2003; Slot et al., 2016) and 13 prospective studies (Ala et al., 2022; Alfadda et al., 2009; Attard et al., 2006; Berretin-Felix et al., 2008; Compagnoni et al., 2014; Coutinho et al., 2021; Emami et al., 2015; Guljé et al., 2012; Jabbour et al., 2012; Matthys et al., 2018, 2019; Reissmann et al., 2018; Tomasi et al., 2013). Among the RCTs, only 2 compared IFCDs and IODs directly (De Kok et al., 2011; Hartmann, Bandeira, et al., 2020). The other RCTs were randomized on the basis of loading protocol ($n=3$), attachment type ($n=3$), implant number ($n=3$), implant type ($n=2$), or comparison to removable complete dentures ($n=2$). The studies on IODs included dPROMs reported by 1407 patients, and the studies on IFCDs by 50 patients. The number of patients refers to the follow-up, which was 1 to 10 years in the IOD group and 1–1.5 years in the IFCD group (Table 1). Two main categories of dPROMs were used: multi-item instruments such as the OHIP, and single items obtained by VAS. Several variants of the OHIP questionnaire, including OHIP-49 ($n=3$), OHIP-14 ($n=4$), and the OHIP-EDENT questionnaire ($n=12$) were used. Various VAS were used for the evaluation of overall treatment ($n=19$), comfort ($n=6$), denture stability ($n=7$), chewing ability ($n=11$), speaking ability ($n=9$), esthetic outcomes ($n=10$), pain while wearing the denture ($n=3$), and denture cleaning ability ($n=3$). Less frequently used dPROMs included several types of multi-item instruments: the Short Form-36 questionnaire (SF-36; $n=2$) measuring general health-related quality of life, the Oral Impact on Daily Performance questionnaire (OIDP; $n=1$), a patient satisfaction score ($n=1$), and the Denture Satisfaction Score (DSS; $n=2$). The ES of included studies ranged from −0.23 to 6.45 (Table 2). The infrequently used questionnaires were applied only to IOD cohorts, whereas OHIP and VAS-based items were used for cohorts with IODs and IFCDs alike. The higher number of dPROMs than the number of studies included in this meta-analysis is due to the fact that some studies applied multiple dPROMs.

The risk of bias analyses showed a low risk of bias in the majority of included RCTs, and in all but one prospective study (Figure 2a,b). The most common reasons why studies were rated as having "some concerns" or a "high risk of bias" were substantial drop-out rates or unclear descriptions of the randomization process.

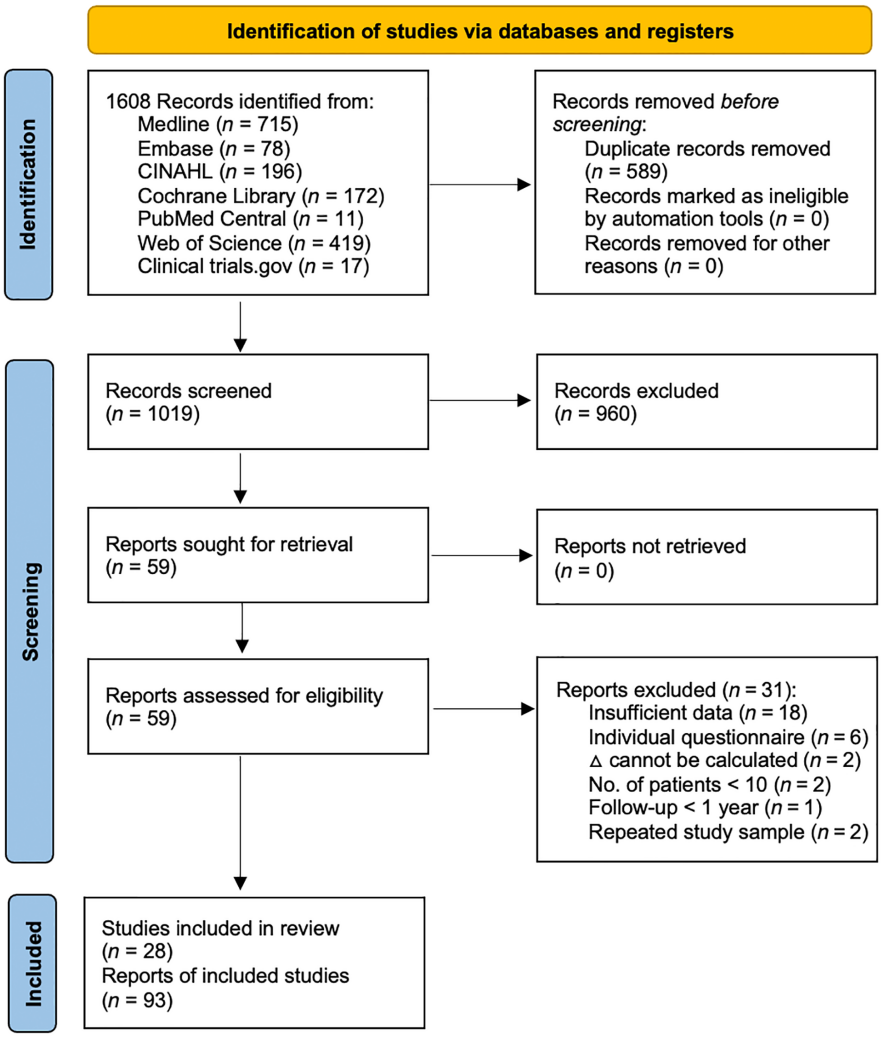
3.2 | Meta analyses

3.2.1 | Fixed complete dentures versus implant overdentures

For the comparison between IFCDs and IODs, only study cohorts with a follow-up period of 1–1.5 years were considered for IODs, as this corresponded to the maximum follow-up period of any IFCD study cohort. Studies ($n=3$) for which no standard deviations were described or could be calculated from the reported data were excluded from the meta-analyses (Compagnoni et al., 2014; de Resende et al., 2021; MacEntee et al., 2005). In the global comparison, results from 52 dPROMs in the IOD group were compared to 12 dPROMs in the IFCD group. There was a high level of heterogeneity among the included studies on IODs ($I^2=86.7\%$) and IFCDs ($I^2=65.9\%$).

Generally, all ES were greater than 0.8, indicating a large effect of implant treatment on dPROs in edentulous patients, independent of the type of restoration. The individual ES from each dPROM are shown in Figure 3. The ES was not significantly different between the IFCD and the IOD groups (ES difference: 0.45 [CI: −0.19, 1.09]; $p=.165$; Table 3). Since only dPROs from OHIP versions and individual items with VAS were included in the cohorts with IFCDs, the data were analyzed separately with respect to these dPROMs. When comparing ES of OHIP data from IOD ($n=10$) and IFCD cohorts ($n=3$), we observed no significant difference (ES difference: −0.03 [CI: −0.58, 0.52]; $p=.920$; Table 3). Within the ES of individual VAS items, only the effect on denture stability was rated higher for the IFCD group than for the IOD group ($p=.032$). No significant differences were detected among

FIGURE 1 PRISMA flow-diagram.



the other individual VAS items, although ES differences were greater than 0.8 in the VASs on comfort, stability, chewing, speaking, and esthetics, in favor of the IFCDs. Based on the GRADE analysis, the certainty of the evidence was rated as moderate or low for all meta-analyses (Table 4).

3.2.2 | Subgroup analyses in implant overdenture groups

Subgroup analyses were conducted for IODs only, as data on IFCDs was insufficient. For the analysis of the influence of the attachment type, only studies with 2–4 implants were considered. Studies with a single implant were excluded because at least 2 implants are required for a bar. For more than 4 implants, there was only one cohort from one study (Slot et al., 2016) with IODs on bars, which was excluded from this analysis due to the lack of comparison with single attachment retained IODs on the same number of implants. Consequently, 20 studies were included for the analysis (Alfadda et al., 2009; Al-Zubeidi et al., 2012; Attard et al., 2006; Bryant et al., 2015; De Kok et al., 2011; De Souza et al., 2015; Emami et al., 2015; Gaballa et al., 2021; Guljé et al., 2012; Hartmann, Bandeira, et al., 2020; Matthys et al., 2018, 2019; Meijer et al., 2003; Michaud et al., 2012; Montero et al., 2021; Park et al., 2019; Raghoebar et al., 2003; Reissmann et al., 2018; Slot et al., 2016; Tomasi et al., 2013). There was no significant difference between bars and single attachments (ES difference: −0.08 [−0.72, 0.56]; Table 5). No ES difference for the OHIP scores could be calculated since OHIP data was only available for single attachment-retained IODs.

There was no significant effect of the mean follow-up period or the number of implants per implant IODs on ES in general (Table 5). However, the ES difference for the direct comparison of single implant- and two implant-retained IODs was significant (0.72 [0.38, 1.06]; $p < .001$), indicating a medium to large difference, based on included studies (Abou-Ayash et al., 2020; Ala et al., 2022; Al-Zubeidi et al., 2012; Bryant et al., 2015; Coutinho et al., 2021; De Kok et al., 2011; De Souza et al., 2015; Gaballa et al., 2021; Hartmann, Bandeira, et al., 2020; Jabbour et al., 2012; Matthys et al., 2018, 2019; Michaud et al., 2012; Montero et al., 2021). The certainty of evidence for all meta-analyses was rated as low, based on the GRADE analysis (Table 6).

TABLE 1 Characteristics of included studies, seperated for each cohort.

Author (year)	Study design|fixed, removable|jaw|retention|antagonist|impl/recon[a]	Mean follow-up [years]	No of pat/recons/impl		Available data
			Baseline	Follow-up	
Abou-Ayash et al. (2020)	RCT|Rem|Mandible|Single|CD|1	2	158|158|158	131|131|131	Mean, SD (BL, FU)
Ala et al. (2022)	Pros|Rem|Mandible|Single|CD|1	1	18|18|18	18|18|18	Mean, SD (BL, FU)
Alfadda et al. (2009)	Pros|Rem|Mandible|Bar|CD|-	5	77|77|234	73|73|-	Mean, SD (BL, FU)
Al-Zubeidi et al. (2012)	RCT|Rem|Mandible|Single|CD|2	5	106|106|212	96|96|192	Mean, SD (BL, FU)
Attard et al. (2006)	Pros|Rem|Mandible|Bar|CD|-	1	35|35|-	35|35|-	Mean, SD (BL, FU)
Berretin-Felix et al. (2008)	Pros|Fixed|Mandible|Screw|CD|5	1.5	15|15|75	15|15|75	Mean, SD (BL, FU)
Bryant et al. (2015)	RCT|Rem|Mandible|Single|CD|1	5	42|42|42	29|29|29	Mean, SD (BL, FU)
Bryant et al. (2015)	RCT|Rem|Mandible|Single|CD|2	5	44|44|88	33|33|66	Mean, SD (BL, FU)
Compagnoni et al. (2014)	Pros|Fixed|Mandible|Screw|CD|4	1	16|16|64	12|12|48	Mean BL, FU
Coutinho et al. (2021)	Pros|Rem|Mandible|Single|CD|1	5	45|45|45	30|30|30	Mean, SD (BL, FU)
de Souza et al. (2015)	RCT|Rem|Mandible|Single|CD|4	1	38|38|152	35|35|133	Mean, SD (BL, FU)
de Souza et al. (2015)	RCT|Rem|Mandible|Single|CD|2	1	42|42|84	36|36|72	Mean, SD (BL, FU)
de Souza et al. (2015)	RCT|Rem|Mandible|Single|CD|2	1	40|40|80	35|35|70	Mean, SD (BL, FU)
de Resende et al. (2021)	RCT|Rem|Mandible|Single|CD|1	1	23|23|23	22|22|22	Mean BL, FU
de Resende et al. (2021)	RCT|Rem|Mandible|Single|CD|2	1	24|24|48	24|24|48	Mean BL, FU
Gaballa et al. (2021)	RCT|Rem|Mandible|Single|CD|2	1	18|18|36	18|18|36	Mean, SD (BL, FU)
Gaballa et al. (2021)	RCT|Rem|Mandible|Single|CD|2	1	18|18|36	18|18|36	Mean, SD (BL, FU)
Emami et al. (2015)	Pros|Rem|Mandible|Single|CD|3	1	135|135|405	135|135|405	Mean, SD (BL, FU)
De Kok et al. (2011)	RCT|Fixed|Mandible|Screw|CD|3	1	20|10|30	10|10|30	Mean, SD (BL, FU)
De Kok et al. (2011)	RCT|Rem|Mandible|Single|CD|2	1	20|10|20	10|10|20	Mean, SD (BL, FU)
Guljé et al. (2012)	Pros|Rem|Mandible|Bar|CD|3	1	12|12|36	12|12|34	Mean, SD (BL, FU)
Hartmann, de Menezes Bandeira, et al. (2020)	RCT|Rem|Mandible|Single|CD|1	1	14|14|14	11|11|11	Mean, SD (BL, FU)
Hartmann, de Menezes Bandeira, et al. (2020)	RCT|Rem|Mandible|Single|CD|2	1	17|17|34	13|13|26	Mean, SD (BL, FU)
Hartmann, de Menezes Bandeira, et al. (2020)	RCT|Fixed|Mandible|Screw|CD|4	1	15|15|52	13|13|52	Mean, SD (BL, FU)
Jabbour et al. (2012)	Pros|Rem|Mandible|Single|CD|1	2	95|95|190	85|85|170	Mean, SD (BL, FU)
MacEntee et al. (2005)	RCT|Rem|Mandible|Bar|CD|2	2	34|34|68	34|34|68	Median (BL, FU)
MacEntee et al. (2005)	RCT|Rem|Mandible|Single|CD|2	2	34|34|68	34|34|68	Median (BL, FU)
Matthys et al. (2019)	Pros|Rem|Mandible|Single|CD|2	5	37|37|74	34|34|68	Mean, SD (BL, FU)
Matthys et al. (2019)	Pros|Rem|Mandible|Single|CD|2	5	69|69|138	56|56|112	Mean, SD (BL, FU)

TABLE 1 (Continued)

Author (year)	Study design|fixed, removable|jaw|retention| antagonist|impl/recon[a]	Mean follow-up [years]	No of pat/recons/impl		Available data
			Baseline	Follow-up	
Matthys et al. (2018)	Pros|Rem|Mandible|Single|CD|2	1.3	25|25|50	25|23|50	Mean, SD (BL, FU)
Meijer et al. (2003)	RCT|Rem|Mandible|Bar|CD|2	10	61|61|122	53|53|106	Mean, SD (BL, FU)
Michaud et al. (2012)	RCT|Rem|Mandible|Single|CD|2	1	116|116|232	110|110|220	Mean, SD (BL, FU)
Montero et al. (2021)	RCT|Rem|Mandible|Single|CD|2	1	20|20|40	20|20|40	Mean, SD (BL, FU)
Park et al. (2019)	RCT|Rem|Maxilla|Single|-|4	1	20|20|-	16|16|-	Mean, SD (BL, FU)
Park et al. (2019)	RCT|Rem|Maxilla|Bar|-|4	1	20|20|-	16|16|-	Mean, SD (BL, FU)
Raghoebar et al. (2003)	RCT|Rem|Mandible|Bar|CD|2	10	32|32|64	28|28|56	Mean, SD (BL, FU)
Reissmann et al. (2018)	Pros|Rem|Mandible|Single|CD|4	1	18|18|72	17|17|-	Mean, SD (BL, FU)
Slot et al. (2016)	RCT|Rem|Maxilla|Bar|-|6	5	25|25|150	22|22|131	Mean, SD (BL, FU)
Slot et al. (2016)	RCT|Rem|Maxilla|Bar|-|4	5	25|25|100	24|24|96	Mean, SD (BL, FU)
Tomasi et al. (2013)	Pros|Rem|Both|Single|Mixed|-	1	21|21|80	19|19|72	Mean, SD (BL, FU)

Abbreviations: antagonist: CD, complete denture; Mixed, overdentures and complete dentures; BL, baseline; FU, follow-up; Fixed, removable: Rem, removable; Pros, Prospective Study; RCT, Randomized Controlled Trial; retention: Single, Single attachment (e.g. ball).

[a]No of implants per reconstruction.

4 | DISCUSSION

The present study systematically analyzed and compared dPROs after IFCD and IOD treatments. Although there was no substantial difference in the comprehensive analyses between the two treatment options in terms of dPROs, stability with IFCDs was perceived by patients as better than with IODs when only this single aspect was considered. In the subgroup analyses of the IOD group, bars showed moderately higher ES than single attachments, although this effect was not statistically significant. IODs retained on two implants were perceived more positively than IODs on one implant only.

The strong positive effect of implant treatment on dPROs, regardless of whether the prosthetic restoration was an IFCD or an IOD, seems to reflect the observed improvements in several objective criteria, such as masticatory efficiency, as described in the literature (ELsyad et al., 2022). Our findings are also concordant with previous literature. Particularly worth mentioning are the two RCTs included here that directly compared IFCD to IOD treatments (De Kok et al., 2011; Hartmann, Bandeira, et al., 2020). The result of the subgroup analysis of the IOD studies in terms of the attachment type suggests that there is no difference between bar- or single attachment-retained/supported IODs. The evidence regarding the effect of the attachment type on dPROs had not been clearly established (Kuoppala et al., 2013; Nejatidanesh et al., 2022). In general, studies have shown that patients are least satisfied with magnet-retained IODs, but no general superiority of bars over single attachments has yet been demonstrated (Cune et al., 2005; Kim et al., 2012), supporting the result of the present study. The ES difference between one and two implants retaining an IOD showed a medium effect of the additional implant, and significantly higher dPROs for two-implant retained IODs. Various studies have shown that even a single implant, increasing the retention of mandibular IODs, has a positive effect on dPROs (Hartmann, Bandeira, et al., 2020; Policastro et al., 2019; Schwindling et al., 2018). However, the result of the present study and also of RCTs that directly compared IODs on one and two implants show that patients' perception is slightly more positive with two implants (Hartmann, Bandeira, et al., 2020; Policastro et al., 2019).

4.1 | Discussion of the methods

While a previous review on dPROs comparing IODs and IFCDs concluded that reporting was inconsistent and prospective high-quality studies were lacking (Yao et al., 2018), the present study showed that the demand for further clinical trials focused on dPROs in edentulous patients was met: 16 of the 28 included studies were from 2015 or later. The analysis of dPROs in edentulous patients is not new, and has been the subject of various systematic reviews (De Bruyn et al., 2015; Yao et al., 2018). However, most of them lacked clear standardization of dPROs and dPROMs. In the present study, dPROs collected with non-identical dPROMs were evaluated by calculating effect sizes (ES) to ensure comparability. The calculation

TABLE 2 Overview of the dPROMS used in each study cohort, including the effect size of the treatment on dPROs.

	Baseline			Follow-up			Effect size
Author (year)	Patients	Mean	SD	Patients	Mean	SD	Hedges g (SE)
Oral Health Impact Profile-49 (OHIP-49)							
De Kok et al. (2011)	20	99.1	69.3	10	18.9	20.5	1.34 (0.45)
De Kok et al. (2011)	20	110.0	41.0	10	20.2	13.6	2.52 (0.54)
Reissmann et al. (2018)	18	39.9	31.7	17	26.5	28.4	0.43 (0.35)
Oral Health Impact Profile-14 (OHIP-14)							
Berretin-Felix et al. (2008)	15	18.0	16.4	15	3.0	12.3	1.01 (0.41)
Matthys et al. (2018)	25	15.6	12.3	25	3.5	4.6	1.28 (0.32)
Matthys et al. (2019)	37	15.0	12.0	34	1.9	3.7	1.43 (0.27)
Matthys et al. (2019)	69	20.2	12.5	56	3.2	5.6	1.69 (0.21)
Oral Health Impact Profile for edentulous patients (OHIP EDENT)							
Ala et al. (2022)	18	12.0	12.9	18	2.5	5.8	0.93 (0.36)
Coutinho et al. (2021)	45	9.7	8.0	30	4.3	5.2	0.77 (0.25)
de Souza et al. (2015)	38	15.2	9.1	35	4.6	4.7	1.43 (0.27)
de Souza et al. (2015)	42	13.9	7.8	36	5.1	5.3	1.29 (0.25)
de Souza et al. (2015)	40	17.6	9.4	35	8.9	7.3	1.02 (0.25)
Emami et al. (2015)	135	56.6	19.3	135	31.1	15.2	1.46 (0.14)
Hartmann, de Menezes Bandeira, et al. (2020)	14	9.0	9.9	11	0.0	9.3	0.90 (0.45)
Hartmann, de Menezes Bandeira, et al. (2020)	17	9.0	8.9	13	2.0	2.9	0.97 (0.41)
Hartmann, de Menezes Bandeira, et al. (2020)	15	7.0	6.5	13	2.0	1.7	0.98 (0.42)
Jabbour et al. (2012)	95	54.9	21.0	85	27.9	9.8	1.61 (0.17)
Michaud et al. (2012)	116	55.0	20.0	110	35.0	17.0	1.07 (0.14)
Montero et al. (2021)	20	13.7	5.1	20	3.2	4.1	2.22 (0.42)
Overall treatment outcome (VAS)							
Ala et al. (2022)	18	60.0	56.3	18	90.0	18.5	0.70 (0.36)
Gaballa et al. (2021)	18	82.2	5.7	18	86.1	5.0	0.71 (0.36)
Gaballa et al. (2021)	18	69.0	3.5	18	76.3	5.8	1.49 (0.39)
Guljé et al. (2012)	12	58.0	14.0	12	90.0	90.0	0.48 (0.44)
Montero et al. (2021)	20	41.0	32.0	20	85.0	14.0	1.75 (0.39)
Al-Zubeidi et al. (2012)	106	30.4	26.5	96	77.9	16.5	2.12 (0.18)
Bryant et al. (2015)	42	38.1	34.8	29	68.8	33.9	0.88 (0.26)
Bryant et al. (2015)	44	48.8	35.6	33	76.8	27.8	0.85 (0.24)
Coutinho et al. (2021)	45	64.7	36.3	30	81.3	28.6	0.49 (0.24)
De Kok et al. (2011)	20	36.8	28.8	10	95.1	7.0	2.36 (0.52)
De Kok et al. (2011)	20	29.2	14.3	10	93.6	8.4	4.93 (0.81)
Hartmann, de Menezes Bandeira, et al. (2020)	14	76.7	57.7	11	96.7	15.5	0.43 (0.43)
Hartmann, de Menezes Bandeira, et al. (2020)	17	63.3	57.2	13	98.3	12.5	0.77 (0.40)
Hartmann, de Menezes Bandeira, et al. (2020)	15	81.7	27.2	13	100.0	0.0	0.89 (0.42)
Meijer et al. (2003)	61	48.0	7.0	53	77.0	9.0	3.60 (0.31)
Park et al. (2019)	20	94.0	10.0	16	94.0	10.0	0.00 (0.35)

TABLE 2 (Continued)

	Baseline			Follow-up			Effect size
Author (year)	Patients	Mean	SD	Patients	Mean	SD	Hedges g (SE)
Park et al. (2019)	20	91.0	11.0	16	93.0	16.0	0.15 (0.35)
Raghoebar et al. (2003)	32	47.0	12.0	28	77.0	9.0	2.77 (0.37)
Tomasi et al. (2013)	21	36.3	31.8	19	93.3	8.0	2.36 (0.43)
Comfort (VAS)							
Ala et al. (2022)	18	45.0	50.7	18	95.0	16.1	1.30 (0.38)
Al-Zubeidi et al. (2012)	106	33.3	27.7	96	77.2	18.0	1.85 (0.17)
Coutinho et al. (2021)	45	65.0	33.3	30	81.0	28.4	0.50 (0.24)
De Kok et al. (2011)	20	21.1	30.7	10	97.5	3.7	2.93 (0.58)
De Kok et al. (2011)	20	29.1	31.1	10	95.0	5.5	2.48 (0.54)
Tomasi et al. (2013)	21	51.0	43.7	19	96.3	8.8	1.38 (0.37)
Stability (VAS)							
Ala et al. (2022)	18	40.0	42.6	18	95.0	26.5	1.51 (0.39)
Gaballa et al. (2021)	18	81.3	6.4	18	85.7	2.4	0.90 (0.36)
Gaballa et al. (2021)	18	80.3	4.7	18	83.7	4.7	0.70 (0.36)
Al-Zubeidi et al. (2012)	106	29.3	29.0	96	76.6	13.1	2.06 (0.18)
Coutinho et al. (2021)	45	59.3	37.6	30	82.7	27.2	0.68 (0.25)
De Kok et al. (2011)	20	17.1	28.8	10	96.4	4.1	3.24 (0.61)
De Kok et al. (2011)	20	24.9	32.5	10	93.7	7.5	2.47 (0.54)
Chewing (VAS)							
Ala et al. (2022)	18	45.0	58.7	18	100.0	16.1	1.25 (0.38)
Gaballa et al. (2021)	18	80.9	3.8	18	85.8	4.3	1.19 (0.38)
Gaballa et al. (2021)	18	79.8	6.1	18	84.8	4.1	0.94 (0.36)
Montero et al. (2021)	20	34.0	27.0	20	80.0	19.0	1.93 (0.40)
Al-Zubeidi et al. (2012)	106	32.4	26.1	96	75.2	18.3	1.88 (0.17)
Coutinho et al. (2021)	45	59.3	37.8	30	83.3	28.1	0.69 (0.25)
De Kok et al. (2011)	20	32.2	30.1	10	94.3	9.2	2.38 (0.53)
De Kok et al. (2011)	20	34.0	27.6	10	91.7	12.9	2.35 (0.52)
Park et al. (2019)	20	87.0	19.0	16	93.0	14.0	0.35 (0.35)
Raghoebar et al. (2003)	32	85.0	22.0	28	94.0	10.0	0.51 (0.27)
Tomasi et al. (2013)	21	37.3	24.6	19	93.0	8.8	2.89 (0.48)
Speaking (VAS)							
Ala et al. (2022)	18	65.0	42.6	18	100.0	16.1	1.06 (0.37)
Gaballa et al. (2021)	18	79.9	3.2	18	81.8	2.6	0.64 (0.35)
Gaballa et al. (2021)	18	78.2	4.3	18	80.7	2.9	0.67 (0.35)
Coutinho et al. (2021)	45	76.3	31.0	30	85.3	24.6	0.31 (0.24)
De Kok et al. (2011)	20	42.0	31.4	10	88.9	9.7	1.73 (0.47)
De Kok et al. (2011)	20	46.8	22.2	10	91.4	8.4	2.30 (0.52)
Park et al. (2019)	20	82.0	21.0	16	90.0	14.0	0.43 (0.35)
Raghoebar et al. (2003)	32	85.0	15.0	28	94.0	9.0	0.71 (0.27)
Tomasi et al. (2013)	21	50.7	47.7	19	94.0	8.8	1.21 (0.36)
Esthetics (VAS)							
Ala et al. (2022)	18	85.0	40.2	18	100.0	10.5	0.50 (0.35)
Gaballa et al. (2021)	18	78.7	1.2	18	79.1	3.0	0.17 (0.34)
Gaballa et al. (2021)	18	78.3	2.9	18	77.8	3.2	−0.16 (0.34)

(Continues)

TABLE 2 (Continued)

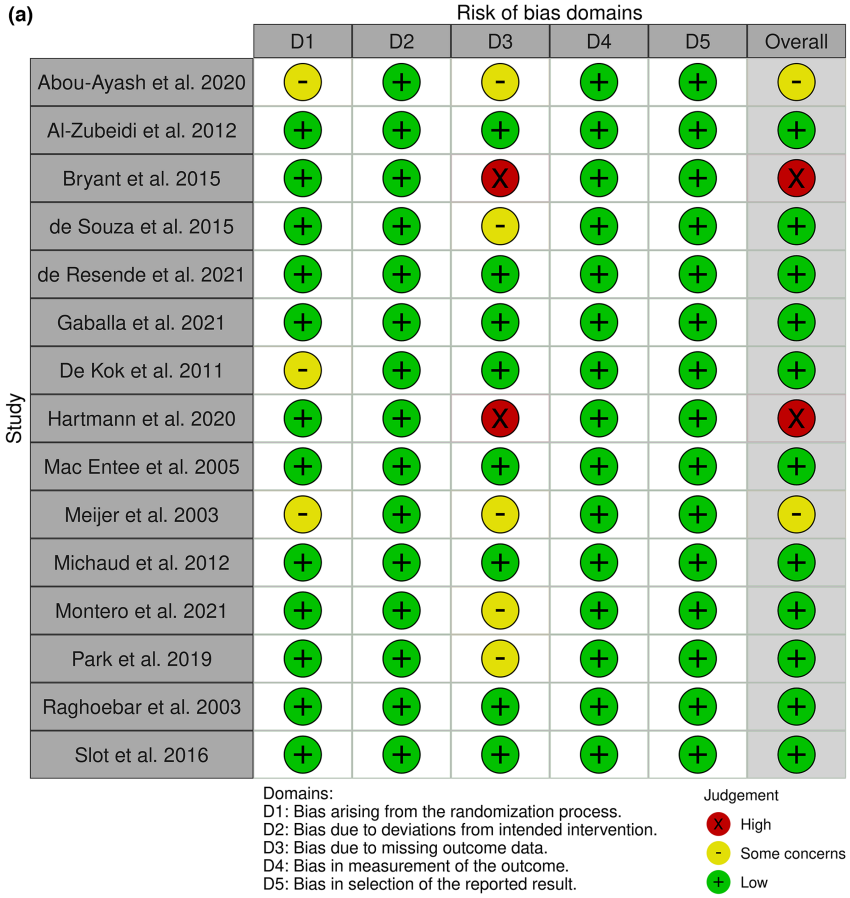
	Baseline			Follow-up			Effect size
Author (year)	Patients	Mean	SD	Patients	Mean	SD	Hedges g (SE)
Montero et al. (2021)	20	51.0	28.0	20	90.0	11.0	1.80 (0.39)
Al-Zubeidi et al. (2012)	106	51.1	29.7	96	77.2	17.9	1.05 (0.15)
Coutinho et al. (2021)	45	89.7	20.0	30	90.3	15.0	0.04 (0.24)
De Kok et al. (2011)	20	48.5	35.6	10	97.5	3.6	1.62 (0.46)
De Kok et al. (2011)	20	37.1	39.2	10	94.9	9.9	1.72 (0.47)
Park et al. (2019)	20	94.0	10.0	16	96.0	11.0	0.19 (0.35)
Raghoebar et al. (2003)	32	92.0	12.0	28	95.0	6.0	0.31 (0.26)
Pain (VAS)							
Al-Zubeidi et al. (2012)	106	40.4	31.5	96	82.1	13.2	1.69 (0.17)
Park et al. (2019)	20	91.0	13.0	16	92.0	18.0	0.06 (0.35)
Raghoebar et al. (2003)	32	75.0	28.0	28	96.0	9.0	0.97 (0.28)
Cleaning (VAS)							
Al-Zubeidi et al. (2012)	106	66.0	24.3	96	80.2	11.5	0.73 (0.15)
De Kok et al. (2011)	20	61.3	36.6	10	89.4	8.8	0.89 (0.42)
De Kok et al. (2011)	20	72.1	21.4	10	96.8	6.2	1.34 (0.45)
Short-Form 36 PCS							
Abou-Ayash et al. (2020)	158	48.1	10.5	131	45.2	14.2	−0.23 (0.12)
Short-Form 36 MCS							
Abou-Ayash et al. (2020)	158	55.7	6.1	131	54.8	7.3	−0.13 (0.12)
Denture satisfaction score (DSS)							
Attard et al. (2006)	35	21.0	2.7	35	6.6	2.1	5.89 (0.57)
Alfadda et al. (2009)	77	21.0	2.7	73	5.8	1.9	6.45 (0.41)
Oral impact on daily performance (OIDP)							
Berretin-Felix et al. (2008)	15	20.0	39.3	15	0.0	14.1	0.66 (0.39)
Patient satisfaction score							
Slot et al. (2016)	25	4.1	1.6	22	9.0	0.7	3.82 (0.52)
Slot et al. (2016)	25	4.3	1.9	24	8.8	1.3	2.71 (0.41)

Abbreviations: MCS, Mental Component Score; PCS, Physical Component Score; SD, standard deviation; SE, standard error.

of ES has been described as a valid tool to compare dPROs across studies (Reissmann, 2021). The consequence of such an approach is that in the respective "overall" effect sizes, summary scores from validated questionnaires containing several items (e.g., OHIP) are treated as equivalent to the results of individual questions (e.g., single items with VAS). At first glance, this approach is at least questionable due to the varying psychometric quality of the dPROMs and the variety of dPRO concepts included in the meta-analyses. This might partially explain the high heterogeneity among the included studies. However, considering the aim of the present study—to analyze the effect of treatment on dPROs in general—and the limited amount of available data, this approach seems to be the best way to generate an initial comparison of the respective treatment effects. Given the questionability of this "overall" approach, also including varying numbers of implants in edentulous maxillae and mandibles, further analyses were performed in the present review to compare individual dimensions of dPROs.

4.2 | Strengths and weaknesses

The major strength of the present systematic review and meta-analysis is the high number of studies that could be included, thanks of the approach of using ES for the analyses. However, the limitation of the small number of studies directly comparing IFCD and IOD treatments remains, as only two RCTs with this direct comparison could be included. While most of the included studies described the effects of implant-based rehabilitation in one jaw with a conventional complete denture as the antagonist, three studies did not include clear information about the opposing dentition (Park et al., 2019; Slot et al., 2016; Tomasi et al., 2013). Since all included studies focused on completely edentulous patients, the antagonists may include conventional complete dentures, IODs, or IFCDs. However, having an IFCD or an IOD as an antagonist is likely to result in different patient ratings, compared to situations with conventional complete dentures, and therefore represents a source of



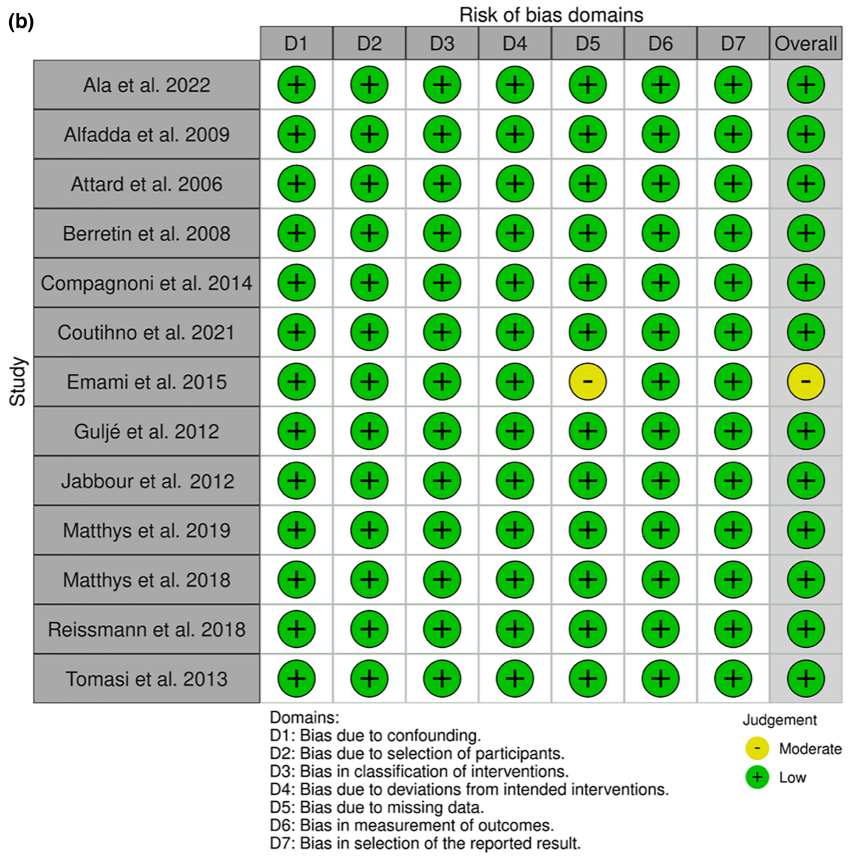


FIGURE 2 (a) Risk of bias analysis of included randomized controlled clinical studies. (b) Risk of bias analysis of included prospective studies.

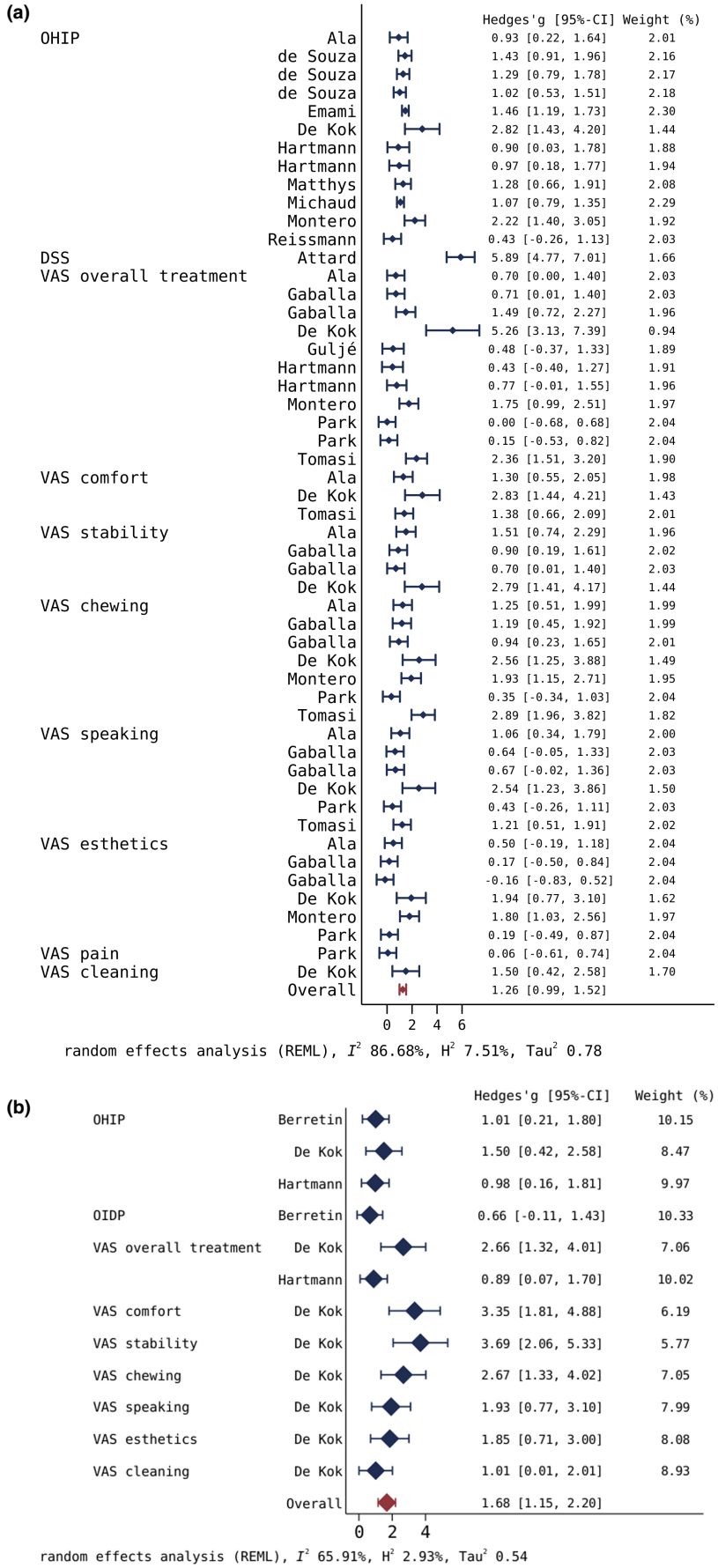


FIGURE 3 (a) Forrest plot of dental patient-reported outcomes from implant-overdenture wearers. (b) Forrest plot of dental patient-reported outcomes from implant-supported fixed complete denture wearers. Abbreviations: DSS, Denture Satisfaction Score; OHIP, Oral Health Impact Profile; OIDP, Oral Impact on Daily Performance; VAS, Visual Analogue Scale.

TABLE 3 Comparison between implant-supported fixed complete dentures (IFCDs) and implant overdentures (IODs); (follow-up: 1–1.5 years).

Outcome	No. of PROMs	Pat. BL	Pat. FU	ES (95% CI)	*p*-Value
All dPROMS					
IODs	52	500	481	1.26 [0.99, 1.52]	0.165
IFCDs	12	40	38	1.68 [1.15, 2.20]	
IFCD vs. IOS (RE)[a]				0.45 [−0.19, 1.09]	
OHIP					
IODs	9	123	116	1.14 [0.91, 1.36]	0.920
IFCDs	3	40	38	1.11 [0.60, 1.61]	
IFCD vs. IOS (RE)[a]				−0.03 [−0.58, 0.52]	
Overall treatment outcome (VAS)					
IODs	11	133	124	1.08 [0.47, 1.70]	0.491
IFCDs	2	25	23	1.69 [−0.04, 3.42]	
IFCD vs. IOS (RE)[a]				0.58 [−1.08, 2.24]	
Comfort (VAS)					
IODs	3	49	47	1.60 [0.95, 2.26]	0.059
IFCDs	1	10	10	3.35 [1.81, 4.88]	
IFCD vs. IOS (RE)[a]				1.74 [−0.07, 3.56]	
Stability (VAS)					
IODs	4	46	46	1.32 [0.58, 2.06]	0.032
IFCDs	1	10	10	3.69 [2.06, 5.33]	
IFCD vs. IOS (RE)[a]				2.37 [0.21, 4.54]	
Chewing (VAS)					
IODs	7	107	101	1.52 [0.86, 2.17]	0.287
IFCDs	1	10	10	2.67 [1.33, 4.02]	
IFCD vs. IOS (RE)[a]				1.16 [−0.97, 3.29]	
Speaking (VAS)					
IODs	6	87	81	0.92 [0.54, 1.30]	0.139
IFCDs	1	10	10	1.93 [0.77, 3.10]	
IFCD vs. IOS (RE)[a]				1.01 [−0.33, 2.35]	
Esthetics (VAS)					
IODs	6	86	82	0.68 [−0.00, 1.36]	0.246
IFCDs	1	10	10	1.85 [0.71, 3.00]	
IFCD vs. IOS (RE)[a]				1.18 [−0.81, 3.17]	
Cleaning (VAS)					
IODs	1	10	10	1.50 [0.42, 2.58]	0.514
IFCDs	1	10	10	1.01 [0.01, 2.01]	
IFCD vs. IOS (FE)[a]				−0.49 [−1.96, 0.98]	

Abbreviations: BL, baseline; dPROMs, dental patient-reported outcome measures; ES, effect size; FU, follow-up; OHIP, Oral Health Impact Profile; VAS, Visual Analogue Scale.

[a]Meta-regression, RE: random-effects meta-regression, FE: fixed-effects meta-regression.

uncertainty. Furthermore, the number of included studies on IFCDs and IODs was not balanced. Previous reviews analyzing edentulous patients have shown that dPROs are collected less frequently in patients rehabilitated with IFCDs than patients with IODs (Messias et al., 2022). In the present systematic review, more than half of IFCD-wearer PROs were obtained from prospective studies, resulting in potential selection bias. This selection bias in combination with the indirectness of the comparison ICFD versus IOD was the main reason for rating the certainty of evidence as low, for most PROMs.

A further limitation of the present systematic review is that the certainty of evidence of each meta-analysis was rated as low or moderate. Nevertheless, the reason for the result of moderate or low certainty rather than very low certainty was mainly the relatively low risk of bias of the included studies. The main reason that the risk of bias of the individual studies in the present systematic review was relatively low is most likely related to the strict inclusion and exclusion criteria (Moons et al., 2019). In particular, the criterion of sufficient reporting baseline and follow-up data led to the exclusion of many studies in which the risk of bias was estimated to be higher.

4.3 | Clinical implications

A combination of the results from the overall analysis and the more specific analyses may be used in the future to counsel patients on the best treatment options for them. This approach may be especially useful in patients seeking improvement in specific areas (i.e., stability and comfort) where the difference between IFCDs and IODs was most obvious. Despite the non-existent differences between IFCD and IOD treatments in terms of most dPROs, patients still do not seem to make a 50:50 decision for one or the other treatment option when given the choice (Heydecke et al., 2003). Individual factors, which should be further analyzed, seem to be influential for this decision. Heydecke et al. have shown that the less complex hygiene procedures of IODs could be the reason why patients who have difficulties with cleaning are more likely to choose an IOD than an IFCD (Heydecke et al., 2003). On the other hand, the present meta-analysis showed that stability with

TABLE 4 Certainty of evidence analysis for the comparison of implant-supported fixed complete dentures (IFCDs) and implant overdentures (IODs).

Outcome	No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Certainty
All dPROMS	15	8 RCTs, 7 non-RCTs	Moderate[a]	Serious[b]	Yes	Serious[c]	Low
OHIP	10	5 RCTs, 5 non-RCTs	Moderate[a]	Serious[b]	Yes	Serious[c]	Low
Overall treatment outcome (VAS)	8	5 RCTs, 3 non-RCTs	Moderate[a]	Serious[b]	Yes	Serious[c]	Low
Comfort (VAS)	3	2 RCTs, 1 non-RCTs	Low[a]	Serious[b]	Yes	Serious[c]	Low
Stability (VAS)	3	2 RCTs, 1 non-RCT	Low[a]	Serious[b]	Yes	Serious[c]	Low
Chewing (VAS)	6	4 RCTs, 2 non-RCTs	Low[a]	Serious[b]	Yes	Serious[c]	Low
Speaking (VAS)	6	4 RCTs, 2 non-RCTs	Low[a]	Serious[b]	Yes	Serious[c]	Low
Esthetics (VAS)	6	4 RCTs, 2 non-RCTs	Low[a]	Serious[b]	Yes	Serious[c]	Low
Cleaning (VAS)	1	1 RCT	Low[a]	No	No	Serious[c]	Moderate

Abbreviations: CI, confidence interval; dPROMs, dental patient-reported outcome measures; OHIP, Oral Health Impact Profile; RCT, randomized controlled trial; VAS, Visual Analogue Scale.

[a]Bias estimation based on risk of bias analyses.

[b]Presence of substantial heterogeneity.

[c]Imprecision due to small sample size especially of IFCD group, and/ or wide confidence intervals.

IFCDs was rated higher. Although this result is based only on dPROs of one cohort of patients treated with IFCDs, it suggests that younger patients looking for stability in their prosthetic restoration would be more likely to opt for an IFCD (Kuoppala et al., 2013).

One of the most frequently asked questions regarding patient information pertains to the cost effectiveness of the treatment options. Since treatment costs vary greatly around the globe, it is difficult to draw generalized conclusions here. Nevertheless, a common approach for comparing cost-effectiveness is to calculate the cost of improvement by one unit to compare two or more treatment options (Briggs & Gray, 1998). Taking the overall results of the present study as an example, the treatment costs for an IFCD and for an IOD can be divided by the factors 1.68 and 1.26, respectively, which represent the ES on overall dPROs of each treatment option. The smaller result then represents the more cost-effective choice in terms of overall dPROs. As the ES in patients treated with ICFDs was 1.33-fold higher than that of patients with IODs, it can be inferred that if the cost of an ICFD is more than 1.33-fold greater than an IOD, treatment with an IOD is more cost-effective with respect to dPROs. Another systematic review and meta-analysis on IODs, as well as a recent RCT comparing IFCDs and IODs concluded that IODs are more cost-effective (Hartmann, de Menezes Bandeira, et al., 2020; Zhang et al., 2017).

The same methodology can be applied to calculate the most cost-effective number of implants for an IOD. Although initial investment costs for IODs on two implants are higher than for IODs on one implant, single implant IODs seem to require a high follow-up effort, especially due to the adjustment of the retention, which may offset the initially lower investment costs over a longer period of time (Hartmann, de Menezes Bandeira, et al., 2020; Kern et al., 2021). A recently published study analyzed masticatory efficiency and OHRQoL in patients restored with IODs first on one, then on two, and subsequently on three implants in the edentulous mandible (Passia et al., 2022). Masticatory efficiency improved with the loading of the second implant, while the third implant had no effect on masticatory efficiency or OHRQoL. Considering these results as well as the findings of the present study, that both showed no effect when more than two implants were used in an IOD, the recommendation of the McGill Consensus Conference to restore edentulous patients with a mandibular IOD on two implants (Feine et al., 2002) can still be supported and thus represent our first treatment option. However, IODs on one implant could be considered as the "minimum standard of care" for the edentulous mandible, as this restoration already leads to an improvement of functional parameters and dPROs (Passia et al., 2017; Policastro et al., 2019). This option could be specifically recommended to patients who have limited possibilities to afford higher one-time treatment costs. More than two implants retaining a mandibular IOD, seem to be unnecessary from a patient's point of view.

4.4 | Implications for future research

Future studies should use dPRO assessment instruments with sufficient psychometric properties and several validated language versions available to ensure high methodological quality and comparability. Such an instrument should measure all four dimensions of OHRQoL, i.e., *Oral Function*, *Orofacial Pain*, *Orofacial Appearance*, and *Psychosocial Impact* (John et al., 2014). The most often applied instrument fulfilling these requirements is the OHIP with its several versions. Even the very short version with only 5 items (OHIP-5) reflects approximately 90% of the information collected in the long (49-item) version and is recommended for most clinical and scientific

TABLE 5 Subgroup analyses in implant overdentures (IODs) focusing on retention type (single attachment vs. bar), influence of the follow-up time, and number of implants per reconstruction.

	No. of dPROMs	Pat. BL	Pat. FU	ES (95% CI)	*p*-Value	Heterogeneity (I^2)
Type of retention						
All dPROMs						
Single	41	584	546	1.38 [1.17, 1.58]		82.0%
Bar	7	105	93	1.33 [0.37, 2.29]		94.5%
Bar vs. single[a]				−0.08 [−0.72, 0.56]	0.804	
OHIP[b]						
Single	9	145	134	1.30 [1.04, 1.55]		42.4%
Mean follow-up (FU) [years]						
all dPROMs						
Mean FU ≤ 2	55	753	697	1.21 [0.94, 1.47]		90.0%
Mean FU 5	21	332	284	1.53 [0.94, 2.12]		97.5%
Mean FU 10	6	93	81	1.46 [0.38, 2.55]		95.5%
Mean FU 5 vs. ≤2[b]				0.29 [−0.28, 0.86]	0.320	
Mean FU = 10 ≤ 2[b]				0.23 [−0.73, 1.19]	0.637	
OHIP						
FU ≤ 2	13	489	466	1.28 [1.07, 1.49]		49.6%
Mean FU = 5	3	82	64	1.30 [0.76, 1.85]		74.7%
Mean FU 5 vs. ≤2[a]				0.03 [−0.46, 0.52]	0.910	
Implants per reconstruction						
all dPROMs						
Impl/Recon 1	20	372	304	0.67 [0.43, 0.91]		79.4%
Impl/Recon 2	38	435	395	1.40 [1.18, 1.62]		82.3%
Impl/Recon 3	1	135	135	1.46 [1.19, 1.73]		
Impl/Recon 4	3	76	68	0.65 [−0.21, 1.50]		81.9%
Implants per recon.[a]				0.22 [−0.03, 0.46	0.081	
OHIP						
Impl/Recon 1	4	172	144	1.11 [0.65, 1.57]		63.7%
Impl/Recon 2	9	267	248	1.37 [1.12, 1.62]		47.0%
Impl/Recon 3	1	135	135	1.46 [1.19, 1.73]		
Impl/Recon 4	2	56	52	0.96 [−0.02, 1.94]		80.3%
Implants per recon.[b]				−0.01 [−0.24, 0.21]	0.925	

Abbreviations: BL, baseline; dPROMs, dental patient-reported outcome measures; ES, effect size; FU, follow-up; Impl/Recon, number of implants per reconstruction; OHIP, oral health impact profile; pat, number of patients.

[a]Meta-regression (random-effects).

[b]No studies available for bar retention.

applications (John et al., 2021, 2022; Reissmann, 2021). Nonetheless, in some cases, it is not only necessary to assess the entire OHRQoL spectrum, but some individual aspects are also of special interest. In these cases, specific questions relevant to the treatment outcome can be used (Leles et al., 2022). To ensure comparability, questions should be chosen that were already applied in other studies on the same or similar topic. Answers to these questions should be collected on commonly accepted response scales, such as VAS, ordinal response scales, or Likert scales. However, given the widespread application of VAS for assessing satisfaction with various treatment outcomes in implant dentistry, the use of a VAS is recommended. Furthermore, since individual factors seem to be very important for decision making, future studies are needed to address these patient-related psychosocial factors. Such information is related to patient values and preferences. Finally, as the commonly accepted scientific standard, prospective studies should report not only differences between treatment groups but also individual scores for each group. That is, reporting of pre-treatment and follow-up scores (including measures for central tendency, e.g., means, and for score variability, e.g., standard deviations) should be mandatory.

TABLE 6 Certainty of evidence analysis for the subgroup analyses within implant overdenture groups (IODs).

Outcome	No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Certainty
Type of retention; all dPROMs	20	14 RCTs, 6 non-RCTs	Moderate[a]	Serious[b]	Yes	Serious[c]	Low
Mean follow-up; all dPROMs	24	15 RCTs, 9 non-RCTs	Moderate[a]	Serious[b]	Yes	Moderate[c]	Moderate
Mean follow-up OHIP	11	6 RCTs, 5 non-RCTs	Low[a]	Serious[b]	Yes	Serious[c]	Low
Implants per reconstruction; all dPROMs	24	15 RCTs, 9 non-RCTs	Moderate[a]	Serious[b]	Yes	Serious[c]	Low
Implants per reconstruction; OHIP	11	6 RCTs, 5 non-RCT	Low[a]	Serious[b]	Yes	Serious[c]	Low

Abbreviations: CI, confidence interval; dPROMs, dental patient-reported outcome measures; OHIP, Oral Health Impact Profile; RCT, randomized controlled trial; VAS, Visual Analogue Scale.

[a]Bias estimation based on risk of bias analyses.

[b]Presence of substantial heterogeneity.

[c]Imprecision due to small sample size, and/or wide confidence intervals.

5 | CONCLUSION

Although data from included dPROMs address slightly different constructs, it can be concluded that overall, implant treatment in edentulous patients generally results in a strong positive effect on dPROs, independent of the type of prosthodontic rehabilitation. IFCDs may be preferable for patients who specifically seek denture stability. Treatment with mandibular implant overdentures on two implants results in better dPROs than on one implant. On the other hand, having more than two implants in an overdenture does not increase dPROs. Due to the low to moderate certainty of evidence, the results of the present study should be interpreted cautiously. More dPRO data, especially from patients rehabilitated with IFCDs, are needed for further comparison between these two treatment options.

AUTHOR CONTRIBUTIONS

S.A-A. & D.R. conceived the idea; M.F. & S.P. performed the literature search, data extraction, and risk of bias analysis, S.A-A. interpreted the data; S.A-A. & D.R. wrote the initial draft; all authors confirmed the final version of the manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Abou-Ayash, S., von Maltzahn, N., Passia, N., Freitag-Wolf, S., Reissmann, D. R., Luthardt, R. G., Mundt, T., Raedel, M., Rammelsberg, P., Wolfart, S., & Kern, M. (2020). Stabilizing mandibular complete dentures by a single midline implant—Influence on quality of life: 2-year results from a randomized clinical trial comparing different loading protocols. *Clinical Oral Investigations*, *24*(2), 927–935. https://doi.org/10.1007/s00784-019-02969-y

Ala, L. A. B., Nogueira, T. E., & Leles, C. R. (2022). One-year prospective study on single short (7-mm) implant overdentures in patients with severely resorbed mandibles. *Clinical Oral Implants Research*, *33*(3), 291–301. https://doi.org/10.1111/CLR.13887

Alfadda, S. A., Attard, N. J., & David, L. A. (2009). Five-year clinical results of immediately loaded dental implants using mandibular overdentures. *The International Journal of Prosthodontics*, *22*(4), 368–373.

Al-Zubeidi, M. I., Alsabeeha, N. H. M., Thomson, W. M., & Payne, A. G. T. (2012). Patient satisfaction and dissatisfaction with mandibular two-implant overdentures using different attachment systems: 5-year outcomes. *Clinical Implant Dentistry and Related Research*, *14*(5), 696–707. https://doi.org/10.1111/J.1708-8208.2010.00306.X

Attard, N. J., Laporte, A., Locker, D., & Zarb, G. A. (2006). A prospective study on immediate loading of implants with mandibular overdentures: patient-mediated and economic outcomes. *The International Journal of Prosthodontics*, *19*(1), 67–73.

Berretin-Felix, G., Nary Filho, H., Padovani, C. R., & Machado, W. M. (2008). A longitudinal study of quality of life of elderly with mandibular implant-supported fixed prostheses. *Clinical Oral Implants Research*, *19*(7), 704–708. https://doi.org/10.1111/J.1600-0501.2007.01451.X

Bressan, E., Tomasi, C., Stellini, E., Sivolella, S., Favero, G., & Berglundh, T. (2012). Implant-supported mandibular overdentures: A cross-sectional study. *Clinical Oral Implants Research*, *23*(7), 814–819. https://doi.org/10.1111/J.1600-0501.2011.02225.X

Briggs, A., & Gray, A. (1998). The distribution of health care costs and their statistical analysis for economic evaluation. *Journal of Health Services Research & Policy*, *3*(4), 233–245. https://doi.org/10.1177/135581969800300410

Bryant, S. R., Walton, J. N., & MacEntee, M. I. (2015). A 5-year randomized trial to compare 1 or 2 implants for implant overdentures. *Journal*

of Dental Research, *94*(1), 36–43. https://doi.org/10.1177/0022034514554224

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1037//0033-2909.112.1.155

Compagnoni, M., Paleari, A., Rodriguez, L., Giro, G., Mendoza Marin, D., & Pero, A. (2014). Impact of replacing conventional complete dentures with implant-supported fixed complete dentures. *The International Journal of Periodontics & Restorative Dentistry*, *34*(6), 833–839. https://doi.org/10.11607/PRD.1732

Cordioli, G., Majzoub, Z., & Castagna, S. (1997). Mandibular overdentures anchored to single implants: A five-year prospective study. *The Journal of Prosthetic Dentistry*, *78*(2), 159–165. https://doi.org/10.1016/S0022-3913(97)70120-3

Coutinho, P. C., Nogueira, T. E., & Leles, C. R. (2021). Single-implant mandibular overdentures: Clinical, radiographic, and patient-reported outcomes after a 5-year follow-up. *Journal of Prosthetic Dentistry*, *128*, 949–955. https://doi.org/10.1016/J.PROSDENT.2021.01.007

Cune, M., van Kampen, F., van der Bilt, A., & Bosman, F. (2005). Patient satisfaction and preference with magnet, bar-clip, and ball-socket retained mandibular implant overdentures: A cross-over clinical trial. *The International Journal of Prosthodontics*, *18*(2), 471. https://doi.org/10.1016/j.prosdent.2005.05.014

De Bruyn, H., Raes, S., Matthys, C., & Cosyn, J. (2015). The current use of patient-centered/reported outcomes in implant dentistry: A systematic review. *Clinical Oral Implants Research*, *26*(Suppl 11), 45–56. https://doi.org/10.1111/CLR.12634

De Kok, I. J., Chang, K.-H., Lu, T.-S., & Cooper, L. F. (2011). Comparison of three-implant-supported fixed dentures and two-implant-retained overdentures in the edentulous mandible: A pilot study of treatment efficacy and patient satisfaction. *The International Journal of Oral & Maxillofacial Implants*, *26*(2), 415–426.

de Resende, G. P., Jordão, L. M. R., de Souza, J. A. C., Schimmel, M., & Leles, C. R. (2021). Single versus two-implant mandibular overdentures using early-loaded titanium-zirconium implants with hydrophilic surface and ball attachments: 1-year randomized clinical trial. *Clinical Oral Implants Research*, *32*(3), 359–368. https://doi.org/10.1111/CLR.13707

De Souza, R. F., Ribeiro, A. B., Della Vecchia, M. P., Costa, L., Cunha, T. R., Reis, A. C., & Albuquerque, R. F. (2015). Mini vs. standard implants for mandibular overdentures: A randomized trial. *Journal of Dental Research*, *94*(10), 1376–1384. https://doi.org/10.1177/0022034515601959

ELsyad, M. A., Tella, E. A. E. S., Mohamed, S. S., & Mahrous, A. I. (2022). Within-patient evaluation of chewing efficiency and maximum bite force of conventional dentures, fixed prostheses, and milled bar overdentures used for all-on-4 implant rehabilitation of atrophied mandibular ridges: A short-term randomized trial. *Clinical Implant Dentistry and Related Research*, *24*(4), 522–531. https://doi.org/10.1111/cid.13104

Emami, E., de Souza, R. F., Bernier, J., Rompré, P., & Feine, J. S. (2015). Patient perceptions of the mandibular three-implant overdenture: A practice-based study. *Clinical Oral Implants Research*, *26*(6), 639–643. https://doi.org/10.1111/CLR.12351

Emami, E., De Souza, R. F., Kabawat, M., & Feine, J. S. (2013). The impact of edentulism on oral and general health. *International Journal of Dentistry*, *2013*, 498305. https://doi.org/10.1155/2013/498305

Feine, J. S., Carlsson, G. E., Awad, M. A., Chehade, A., Duncan, W. J., Gizani, S., Head, T., Heydecke, G., Lund, J. P., MacEntee, M., Mericske-Stern, R., Mojon, P., Morais, J. A., Naert, I., Payne, A. G., Penrod, J., Stoker, G. T., Tawse-Smith, A., Taylor, T. D., … Wismeijer, D. (2002). The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. *Gerodontology*, *19*(1), 3–4.

Gaballa, O. A., Hamed, H. A. E. F., Fayyad, A. E., & Rahhal, M. M. (2021). Overdentures supported by mini or conventional implants-effect on patient satisfaction and bone resorption rates. A randomized clinical trial. *Open Access Macedonian Journal of Medical Sciences*, *9*(D), 300–313. https://doi.org/10.3889/oamjms.2021.7126

Goulet-Pelletier, J.-C., & Cousineau, D. (2018). A review of effect sizes and their confidence intervals, part I: The Cohen's d family. *Quantitative Methods for Psychology*, *14*(4), 242–265. https://doi.org/10.20982/TQMP.14.4.P242

Guljé, F., Raghoebar, G. M., Ter Meulen, J. W. P., Vissink, A., & Meijer, H. J. A. (2012). Mandibular overdentures supported by 6-mm dental implants: A 1-year prospective cohort study. *Clinical Implant Dentistry and Related Research*, *14*(Suppl 1), e59–e66. https://doi.org/10.1111/J.1708-8208.2011.00358.X

Hartmann, R., Bandeira, A. C. F. d. M., Araújo, S. C. d., Brägger, U., Schimmel, M., & Leles, C. R. (2020). A parallel 3-group randomised clinical trial comparing different implant treatment options for the edentulous mandible: 1-year effects on dental patient-reported outcomes and chewing function. *Journal of Oral Rehabilitation*, *47*(10), 1264–1277. https://doi.org/10.1111/JOOR.13070

Hartmann, R., de Menezes Bandeira, A. C. F., de Araújo, S. C., McKenna, G., Brägger, U., Schimmel, M., & Leles, C. R. (2020). Cost-effectiveness of three different concepts for the rehabilitation of edentulous mandibles: Overdentures with 1 or 2 implant attachments and hybrid prosthesis on four implants. *Journal of Oral Rehabilitation*, *47*(11), 1394–1402. https://doi.org/10.1111/JOOR.13071

Heydecke, G., Boudrias, P., Awad, M. A., De Albuquerque, R. F., Lund, J. P., & Feine, J. S. (2003). Within-subject comparisons of maxillary fixed and removable implant prostheses. *Clinical Oral Implants Research*, *14*(1), 125–130. https://doi.org/10.1034/J.1600-0501.2003.140117.X

Higgins, J. P. T., Altman, D. G., Gøtzsche, P. C., Jüni, P., Moher, D., Oxman, A. D., Savovic, J., Schulz, K. F., Weeks, L., Sterne, J. A., Cochrane Bias Methods Group, & Cochrane Statistical Methods Group. (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ*, *343*(7829), d5928. https://doi.org/10.1136/BMJ.D5928

Jabbour, Z., Emami, E., de Grandmont, P., Rompré, P. H., & Feine, J. S. (2012). Is oral health-related quality of life stable following rehabilitation with mandibular two-implant overdentures? *Clinical Oral Implants Research*, *23*(10), 1205–1209. https://doi.org/10.1111/J.1600-0501.2011.02289.X

John, M. T., Feuerstahler, L., Waller, N., Baba, K., Larsson, P., Čelebić, A., Kende, D., Rener-Sitar, K., & Reissmann, D. R. (2014). Confirmatory factor analysis of the oral health impact profile. *Journal of Oral Rehabilitation*, *41*(9), 644–652. https://doi.org/10.1111/JOOR.12191

John, M. T., Omara, M., Su, N., List, T., Sekulic, S., Häggman-Henrikson, B., Visscher, C. M., Bekes, K., Reissmann, D. R., Baba, K., Schierz, O., Theis-Mahon, N., Fueki, K., Stamm, T., Bondemark, L., Oghli, I., van Wijk, A., & Larsson, P. (2022). Recommendations for use and scoring of oral health impact profile versions. *The Journal of Evidence-Based Dental Practice*, *22*(1), 101619. https://doi.org/10.1016/J.JEBDP.2021.101619

John, M. T., Rener-Sitar, K., Baba, K., Čelebić, A., Larsson, P., Szabo, G., Norton, W. E., & Reissmann, D. R. (2016). Patterns of impaired oral health-related quality of life dimensions. *Journal of Oral Rehabilitation*, *43*(7), 519–527. https://doi.org/10.1111/JOOR.12396

John, M. T. (2018). Health outcomes reported by dental patients. *The Journal of Evidence-Based Dental Practice*, *1–4*, 332–335. https://doi.org/10.1016/j.jebdp.2018.09.001

John, M. T., Häggman-Henrikson, B., Sekulic, S., Stamm, T., Oghli, I., Schierz, O., List, T., Baba, K., Bekes, K., van Wijk, A., Su, N., Reissmann, D. R., Fueki, K., Larsson, P., Theis-Mahon, N., Omara, M., Bondemark, L., & Visscher, C. M. (2021). Mapping oral disease impact with a common metric (MOM)-project summary and recommendations. *Journal of Oral Rehabilitation*, *48*(3), 305–307. https://doi.org/10.1111/JOOR.13133

Joshipura, K. J., Willett, W. C., & Douglass, C. W. (1996). The impact of edentulousness on food and nutrient intake. *Journal of the*

American Dental Association (1939), *127*(4), 459–467. https://doi.org/10.14219/JADA.ARCHIVE.1996.0237

Kassebaum, N. J., Smith, A. G. C., Bernabé, E., Fleming, T. D., Reynolds, A. E., Vos, T., Murray, C. J. L., Marcenes, W., & Yonemoto, N. (2017). Global, regional, and National Prevalence, incidence, and disability-adjusted life years for oral conditions for 195 countries, 1990–2015: A systematic analysis for the global burden of diseases, injuries, and risk factors. *Journal of Dental Research*, *96*(4), 380–387. https://doi.org/10.1177/0022034517693566

Kern, M., Behrendt, C., Fritzer, E., Kohal, R. J., Luthardt, R. G., Maltzahn, N. F., Rädel, M., Reissmann, D. R., Schwindling, F. S., Wolfart, S., & Passia, N. (2021). 5-year randomized multicenter clinical trial on single dental implants placed in the midline of the edentulous mandible. *Clinical Oral Implants Research*, *32*(2), 212–221. https://doi.org/10.1111/CLR.13692

Kim, H. Y., Lee, J. Y., Shin, S. W., & Ross Bryant, S. (2012). Attachment systems for mandibular implant overdentures: A systematic review. *The Journal of Advanced Prosthodontics*, *4*(4), 197–203. https://doi.org/10.4047/JAP.2012.4.4.197

Kuoppala, R., Näpänkangas, R., & Raustia, A. (2013). Quality of life of patients treated with implant-supported mandibular overdentures evaluated with the Oral health impact profile (OHIP-14): A survey of 58 patients. *Journal of Oral & Maxillofacial Research*, *4*(2), e4. https://doi.org/10.5037/JOMR.2013.4204

Leles, C. R., Silva, J. R., Curado, T. F. F., Schimmel, M., & McKenna, G. (2022). The Potential Role of Dental Patient-Reported Outcomes (dPROs) in Evidence-Based Prosthodontics and Clinical Care: A Narrative Review. *Patient Related Outcome Measures*, *13*, 131–143. https://doi.org/10.2147/PROM.S256724

MacEntee, M. I., Walton, J. N., & Glick, N. (2005). A clinical trial of patient satisfaction and prosthodontic needs with ball and bar attachments for implant-retained complete overdentures: Three-year results. *Journal of Prosthetic Dentistry*, *93*(1), 28–37. https://doi.org/10.1016/j.prosdent.2004.10.013

Matthys, C., Vervaeke, S., Besseler, J., Doornewaard, R., Dierens, M., & De Bruyn, H. (2019). Five years follow-up of mandibular 2-implant overdentures on locator or ball abutments: Implant results, patient-related outcome, and prosthetic aftercare. *Clinical Implant Dentistry and Related Research*, *21*(5), 835–844. https://doi.org/10.1111/CID.12840

Matthys, C., Vervaeke, S., Jacquet, W., & De Bruyn, H. (2018). Impact of crestal bone resorption on quality of life and professional maintenance with conventional dentures or locator-retained mandibular implant overdentures. *The Journal of Prosthetic Dentistry*, *120*(6), 886–894. https://doi.org/10.1016/J.PROSDENT.2017.11.028

Meijer, H. J. A., Raghoebar, G. M., & Van't Hof, M. A. (2003). Comparison of implant-retained mandibular overdentures and conventional complete dentures: A 10-year prospective study of clinical aspects and patient satisfaction. *The International Journal of Oral & Maxillofacial Implants*, *18*(6), 879–885.

Messias, A., Karasan, D., Nicolau, P., Pjetursson, B. E., & Guerra, F. (2022). Rehabilitation of full-arch edentulism with fixed or removable dentures retained by root-form dental implants: A systematic review of outcomes and outcome measures used in clinical research in the last 10 years. *Clinical Oral Implants Research*. [Online ahead of print]. https://doi.org/10.1111/CLR.13931

Messias, A., Nicolau, P., & Guerra, F. (2021). Different Interventions for Rehabilitation of the Edentulous Maxilla with Implant-Supported Prostheses: An Overview of Systematic Reviews. *The International Journal of Prosthodontics*, *34*, s63–s84. https://doi.org/10.11607/ijp.7162

Michaud, P. L., De Grandmont, P., Feine, J. S., & Emami, E. (2012). Measuring patient-based outcomes: Is treatment satisfaction associated with oral health-related quality of life? *Journal of Dentistry*, *40*(8), 624–631. https://doi.org/10.1016/J.JDENT.2012.04.007

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Annals of Internal Medicine*, *151*(4), 264–269, W64.

Montero, J., Dib, A., Guadilla, Y., Flores, J., Pardal-Peláez, B., Quispe-López, N., & Gómez-Polo, C. (2021). Functional and patient-centered treatment outcomes with mandibular overdentures retained by two immediate or conventionally loaded implants: A randomized clinical trial. *Journal of Clinical Medicine*, *10*(16), 3477. https://doi.org/10.3390/JCM10163477

Moons, K. G. M., Wolff, R. F., Riley, R. D., Whiting, P. F., Westwood, M., Collins, G. S., Reitsma, J. B., Kleijnen, J., & Mallett, S. (2019). PROBAST: A tool to assess risk of bias and applicability of prediction model studies: Explanation and elaboration. *Annals of Internal Medicine*, *170*(1), W1–W33. https://doi.org/10.7326/M18-1377

Mustafa, R. A., Santesso, N., Brozek, J., Akl, E. A., Walter, S. D., Norman, G., Kulasegaram, M., Christensen, R., Guyatt, G. H., Falck-Ytter, Y., Chang, S., Murad, M. H., Vist, G. E., Lasserson, T., Gartlehner, G., Shukla, V., Sun, X., Whittington, C., Post, P. N., … Schünemann, H. J. (2013). The GRADE approach is reproducible in assessing the quality of evidence of quantitative evidence syntheses. *Journal of Clinical Epidemiology*, *66*(7), 736–742. https://doi.org/10.1016/J.JCLINEPI.2013.02.004

Nejatidanesh, F., Bonakdarchian, H., Savabi, G., Bonakdarchian, M., Atash, R., & Savabi, O. (2022). Clinical performance of implant supported mandibular overdentures with cantilever bar and stud attachments: A retrospective study. *Clinical Implant Dentistry and Related Research*, *24*, 845–853. https://doi.org/10.1111/CID.13131

Park, J. H., Shin, S. W., & Lee, J. Y. (2019). Bar versus ball attachments for maxillary four-implant retained overdentures: A randomized controlled trial. *Clinical Oral Implants Research*, *30*(11), 1076–1084. https://doi.org/10.1111/CLR.13521

Passia, N., Abou-Ayash, S., Reissmann, D. R., Fritzer, E., Kappel, S., Konstantinidis, I., Königsmarck, V. V., Mundt, T., Stiesch, M., Wolfart, S., Ali, S., & Kern, M. (2017). Single mandibular implant study (SMIS) – Masticatory performance – Results from a randomized clinical trial using two different loading protocols. *Journal of Dentistry*, *65*, 64–69. https://doi.org/10.1016/j.jdent.2017.07.005

Passia, N., Chaar, M. S., Krummel, A., Nagy, A., Freitag-Wolf, S., Ali, S., & Kern, M. (2022). Influence of the number of implants in the edentulous mandible on chewing efficacy and oral health-related quality of life—A within-subject design study. *Clinical Oral Implants Research*, *33*(10), 1030–1037. https://doi.org/10.1111/clr.13984

Peres, M. A., Macpherson, L. M. D., Weyant, R. J., Daly, B., Venturelli, R., Mathur, M. R., Listl, S., Celeste, R. K., Guarnizo-Herreño, C. C., Kearns, C., Benzian, H., Allison, P., & Watt, R. G. (2019). Oral diseases: A global public health challenge. *Lancet*, *394*(10194), 249–260. https://doi.org/10.1016/S0140-6736(19)31146-8

Policastro, V. B., Paleari, A. G., Leite, A. R. P., Mendoza-Marin, D. O., Cassiano, A. F. B., Shaddox, L. M., Compagnoni, M. A., & Pero, A. C. (2019). A randomized clinical trial of Oral health-related quality of life, Peri-implant and Kinesiograph parameters in wearers of one-or two-implant mandibular overdentures. *Journal of Prosthodontics: Official Journal of the American College of Prosthodontists*, *28*(7), 757–765. https://doi.org/10.1111/JOPR.12796

Polzer, I., Schimmel, M., Müller, F., & Biffar, R. (2010). Edentulism as part of the general health problems of elderly adults. *International Dental Journal*, *60*(3), 143–155. https://doi.org/10.1922/IDJ-2184Polzer13

Raghoebar, G. M., Meijer, H. J. A., van't Hof, M., Stegenga, B., & Vissink, A. (2003). A randomized prospective clinical trial on the effectiveness of three treatment modalities for patients with lower denture problems: A 10 year follow-up study on patient satisfaction.

International Journal of Oral and Maxillofacial Surgery, *32*(5), 498–503. https://doi.org/10.1016/S0901-5027(03)90434-0

Reissmann, D. R. (2019). Dental patient-reported outcome measures are essential for evidence-based prosthetic dentistry. *The Journal of Evidence-Based Dental Practice*, *19*(1), 1–6. https://doi.org/10.1016/J.JEBDP.2019.01.003

Reissmann, D. R. (2021). Methodological considerations when measuring oral health-related quality of life. *Journal of Oral Rehabilitation*, *48*(3), 233–245. https://doi.org/10.1111/JOOR.12983

Reissmann, D. R., Dard, M., Lamprecht, R., Struppek, J., & Heydecke, G. (2017). Oral health-related quality of life in subjects with implant-supported prostheses: A systematic review. *Journal of Dentistry*, *65*, 22–40. https://doi.org/10.1016/J.JDENT.2017.08.003

Reissmann, D. R., Enkling, N., Moazzin, R., Haueter, M., Worni, A., & Schimmel, M. (2018). Long-term changes in oral health-related quality of life over a period of 5 years in patients treated with narrow diameter implants: A prospective clinical study. *Journal of Dentistry*, *75*, 84–90. https://doi.org/10.1016/J.JDENT.2018.05.019

Rodrigues, S. M., Oliveira, A. C., Vargas, A. M. D., Moreira, A. N., & Ferreira, E. (2012). Implications of edentulism on quality of life among elderly. *International Journal of Environmental Research and Public Health*, *9*(1), 100–109. https://doi.org/10.3390/IJERPH9010100

Schierz, O., & Reissmann, D. R. (2021). Dental patient-reported outcomes – The promise of dental implants. *The Journal of Evidence-Based Dental Practice*, *21*(1), 101541. https://doi.org/10.1016/J.JEBDP.2021.101541

Schwendicke, F., Nitschke, I., Stark, H., Micheelis, W., & Jordan, R. A. (2020). Epidemiological trends, predictive factors, and projection of tooth loss in Germany 1997–2030: Part II. Edentulism in seniors. *Clinical Oral Investigations*, *24*(11), 3997–4003. https://doi.org/10.1007/s00784-020-03265-w

Schwindling, F. S., Raedel, M., Passia, N., Freitag-Wolf, S., Wolfart, S., Att, W., Mundt, T., Reissmann, D., Ismail, F., von Königsmark, V., & Kern, M. (2018). The single mandibular implant study – Short-term effects of the loading protocol on oral health-related quality of life. *Journal of Prosthodontic Research*, *62*(3), 313–316. https://doi.org/10.1016/J.JPOR.2017.12.003

Slot, W., Raghoebar, G. M., Cune, M. S., Vissink, A., & Meijer, H. J. (2016). Maxillary overdentures supported by four or six implants in the anterior region: 5-year results from a randomized controlled trial. *Journal of Clinical Periodontology*, *43*(12), 1180–1187. https://doi.org/10.1111/jcpe.12625

Soto-Peñaloza, D., Zaragozí-Alonso, R., Peñarrocha-Diago, M., & Peñarrocha-Diago, M. (2017). The all-on-four treatment concept: Systematic review. *Journal of Clinical and Experimental Dentistry*, *9*(3), e474–e488. https://doi.org/10.4317/JCED.53613

Sterne, J. A., Hernán, M. A., Reeves, B. C., Savović, J., Berkman, N. D., Viswanathan, M., Henry, D., Altman, D. G., Ansari, M. T., Boutron, I., Carpenter, J. R., Chan, A. W., Churchill, R., Deeks, J. J., Hróbjartsson, A., Kirkham, J., Jüni, P., Loke, Y. K., Pigott, T. D., … Higgins, J. P. (2016). ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*, *355*, i4919. https://doi.org/10.1136/BMJ.I4919

Tomasi, C., Idmyr, B. O., & Wennström, J. L. (2013). Patient satisfaction with mini-implant stabilised full dentures. A 1-year prospective study. *Journal of Oral Rehabilitation*, *40*(7), 526–534. https://doi.org/10.1111/JOOR.12053

Wan, X., Wang, W., Liu, J., & Tong, T. (2014). Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Medical Research Methodology*, *14*(1), 1–13. https://doi.org/10.1186/1471-2288-14-135

Yao, C. J., Cao, C., Bornstein, M. M., & Mattheos, N. (2018). Patient-reported outcome measures of edentulous patients restored with implant-supported removable and fixed prostheses: A systematic review. *Clinical Oral Implants Research*, *29*(Suppl 16), 241–254. https://doi.org/10.1111/CLR.13286

Zhang, Q., Jin, X., Yu, M., Ou, G., Matsui, H., & Liang, X. (2017). Economic evaluation of implant-supported overdentures in edentulous patients: A systematic review. *The International Journal of Prosthodontics*, *30*(4), 321–326. https://doi.org/10.11607/ijp.5023

SUPPORTING INFORMATION

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