Efficacy of Nonreconstructive Surgical Treatment of Peri-implantitis: An AAP/AO Systematic Review and Meta-analysis of Access Flap Versus Osseous Surgery Procedures

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Purpose: To estimate and compare the effect of two different nonreconstructive surgical techniques for treating peri-implantitis. ***Materials and Methods:*** An electronic search was performed in PubMed, Web of Science, Embase, Scopus, Ovid Medline, and the Cochrane Library of the Cochrane Collaboration (CENTRAL) for articles published until September 2023. Studies evaluating surgical nonreconstructive techniques for the treatment of peri-implantitis were included. The primary outcomes were changes in pocket probing depth (PPD) and bleeding on probing (BoP). Secondary outcomes included marginal bone levels (MBLs) and plaque index (PI) changes. Meta-analysis and meta-regression were performed. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach was used to determine the quality of evidence. Results were grouped according to their treatment techniques: *(1)* flap surgeries and *(2)* osseous resective surgeries (nonreconstructive). ***Results:*** The final stage of screening included 15 clinical trials. At 12 months, the flap group had a mean PPD reduction of 1.27 mm (95% CI: 0.67–1.87; I^2 = 95.9%), and the osseous resective group had a PPD reduction of 1.88 mm (95% CI: 1.39–2.37; I^2 = 97.1%), showing no significant differences (P = .119). Regarding BoP, there were no significant differences between the two techniques at 3, 6, or 12 months. For MBL, at 12 months, the flap group showed less bone loss than the osseous resective group (mean difference = 0.73 mm; P < .001). ***Conclusions:*** Both nonreconstructive surgical interventions were effective in managing peri-implantitis. Moderate-quality evidence suggested that flap surgeries may provide a slight advantage in maintaining MBLs compared to osseous resective surgery.
Int J Oral Maxillofac Implants 2025;40(suppl):s73–s90. doi: 10.11607/jomi.2025suppl3

Keywords: dental implants, peri-implantitis, systematic review, therapy

Peri-implantitis—a condition with high prevalence characterized by the extensive destruction of surrounding tissues—has emerged as a significant concern in dental health, drawing attention to its poor therapeutic response and increasing incidence rate.[1] Recent systematic reviews have highlighted alarming prevalence rates at both the patient and implant level,[2,3] with a cross-sectional study[4] reporting even higher rates of 34% at the patient level and 21% at the implant level. The prevalence of peri-implantitis tends to increase with the prolonged functional loading of an implant,[5] presenting a major challenge regarding the numerous implants placed in recent decades.

While nonsurgical therapy for periodontitis has been effective,[6] the same cannot be said for managing peri-implantitis, particularly in established or advanced forms, as the results have often been suboptimal and unpredictable.[7] Despite various nonsurgical treatment methods, there has been an inability to achieve a corresponding reduction in inflammatory parameters at peri-implantitis sites.[7,8] Following the stepwise approach implemented for advanced periodontitis,[9] it has been generally observed that initial nonsurgical therapy of peri-implantitis often necessitates further surgical intervention due to a failure to reach treatment objectives.[10–12]

Surgical techniques such as pocket elimination, access flap procedures, osseous resection, and reconstructive surgeries have been explored extensively.[13–15] These techniques aim to eliminate peri-implant pocket probing depth (PPD) and reduce bleeding on probing (BoP), which are both endpoints desired in periodontal therapy.[16]

During pocket-elimination procedures, soft tissue flaps are apically displaced and resutured at the crestal

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bone level, sometimes involving a resection of sharp bony edges to facilitate flap adaptation.[10,17,18] Flap procedures involve repositioning soft tissue flaps upon decontaminating implant surfaces at the presurgical level, typically maintaining the full height of the mucosal component and the underlying bony structures supporting peri-implant soft tissues.[19,20] Reconstructive surgery extends the access flap technique to address the reconstruction of peri-implantitis–associated angular bony defects, often involving the use of bone substitute materials, barrier membranes, bioactive agents, or combinations thereof.[19,21,22]

However, it is yet to be conclusively demonstrated whether these techniques effectively improve clinical and patient-reported outcomes.[23] Although some studies have reported significant improvements in clinical and imaging parameters with graft materials,[14] others have not found additional improvement in probing depth (PD) or other clinical parameters.[24] The results of reviews and meta-analyses on the effect of graft materials in treating peri-implantitis have been similarly inconsistent.[25–27] Recent randomized controlled trials (RCTs) with these procedures have provided additional evidence, contributing to the formation of more credible conclusions.[14]

Even though significant differences in outcomes were not consistently observed when comparing the efficacy of flap surgery versus resective osseous surgery for managing periodontitis,[28] some studies have implied the potential advantages of osseous resection.[29,30] Given the parallels between periodontal disease and peri-implant disease, it is hypothesized that a similar relationship may be observed in the treatment outcomes of peri-implant disease.

Therefore, this systematic review and network meta-analysis aimed to estimate the effect of access flap procedures versus peri-implant osseous procedures for nonreconstructive surgical treatment of peri-implantitis.

MATERIALS AND METHODS

Protocol and Registration

The present systematic review was registered at the Prospective Register of Systematic Reviews (PROSPERO; CRD42023495793) (https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=495793).

Eligibility

The following population, intervention, comparison, and outcomes (PICOS) framework was used to guide the inclusion and exclusion of studies:

- **P** *(population):* Patients requiring treatment for peri-implantitis with at least one dental implant that was previously in function. Their diagnosis should be specified according to the case definition outlined by the American Academy of Periodontology and European Federation of Periodontology 2017 World Workshop[31–33] or a clear diagnosis based on clinical and radiographic parameters.
- **I** *(intervention)*: Any surgical therapy rendered for the treatment of peri-implantitis to re-establish peri-implant health while performing a "resective" approach without employing any regenerative or augmentation procedures.
- **C** *(comparison)*: Other surgical treatment of peri-implantitis through open flap debridement alone (positive control) or other nonreconstructive surgical therapies.
- **O** *(outcomes)*: For inclusion, studies had to provide at least one of the following outcomes after the rendered treatment: changes in PPD with BoP and/or suppuration (SUP) (primary outcome[s]). The secondary clinical outcomes were as follows: radiographic changes in marginal bone levels (MBLs), plaque index (PI), composite outcomes, disease resolution, implant loss/survival, recession, and other side effects.

Focused Questions

In patients requiring treatment of peri-implantitis (P), this study aimed to estimate the effect of nonregenerative surgical access flap procedures (I) when compared to nonsurgical therapy (C), as measured by the reduction of PD or of BoP (O). When observed in controlled trials with a follow-up of ≥ 6 months and a sample size of ≥ 10 patients per arm (S), which procedure will have the greatest effect on peri-implantitis?

Study Design

For a detailed analysis, all prospectively conducted and controlled human studies that were published in a peer-reviewed journal with at least a 6-month follow-up (after the final intervention in case of repeated delivery/administration of agents) and a minimum of 10 patients per treatment arm were considered for this systematic review. Studies had to delineate a clear description of the rendered treatment.

Search Methodology

Preferred Reporting Items for Systematic Review and Network Meta-Analyses (PRISMA 2020) guidelines were followed in reporting.[34] An electronic search was performed in PubMed, Web of Science, Embase, Scopus, Ovid Medline, and The Cochrane Library of the Cochrane Collaboration (CENTRAL) for articles published until September 2023. Searches were expanded to

include articles in the English and Spanish languages and included hand searching.

Study Selection

Titles and abstracts of relevant studies obtained from the electronic libraries were saved in EndNote (Clarivate Analytics). After the initial search, all studies were uploaded to the Rayyan systematic review platform (Rayyan Systems). Initial calibration of reviewers was achieved by in-person meetings. Two reviewers (M.H.A.S. and A.A.) independently screened titles and abstracts and downloaded full texts through the University of Michigan electronic library. Conflicts were resolved through discussion with a third author (R.N.). If an article was excluded, the reason for exclusion was recorded.

Risk of Bias in Individual Studies

Risk-of-bias assessments were performed by the same two authors (M.H.A.S. and A.A.). If there was disagreement, a third reviewer (R.N.) was consulted. The evaluation of bias risk was conducted using the Cochrane RoB 2 tool.[35] The assessment included five key domains: *(1)* bias in the randomization process (selection bias), *(2)* bias from deviations in planned interventions (adherence to interventions), *(3)* bias from missing data (outcome data completeness), *(4)* bias in outcome measurement, and *(5)* bias in the reporting of results. Each domain addresses a distinct aspect of trial design and execution, contributing to the inclusive bias risk assessment.

Quality of the Evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach along with the GRADEpro were used to assess the quality of evidence for each outcome to measure the efficacy of peri-implantitis treatment using flap surgery versus osseous surgery. The determination of the quality of evidence was based on the following factors: *(1)* the risk of bias across the studies, *(2)* any inconsistencies in the findings, *(3)* imprecision of the study's results, and *(4)* indirectness, as well as *(5)* the magnitude of the effect, *(6)* plausible confounding factors, and *(7)* the dose response.

Statistical Analysis

Weighted means were estimated from a random-effects model with corresponding Z statistics, 95% confidence intervals (CIs), and *P* values. A restricted maximum-likelihood estimator was used in the model. The effect of the type of surgery (flap vs osseous) was estimated using mixed-effects models (meta-regression). Heterogeneity analyses were carried out through Cochran's Q test and I^2 index, which represented the amount of variability between studies compared to total variability. Funnel graphs were performed to assess the potential publication bias, and Egger's test was applied to contrast the present hypothesis. The level of significance used in the analysis was 5% ($\alpha = .05$). The software used was R 4.3.1 (R Foundation for Statistical Computing; https://www.r-project.org).

RESULTS

Selection of Studies

Our electronic search using preset keywords yielded 666 articles. After removing duplicates with the EndNote software, we uploaded 475 articles to the Rayyan systematic review platform for an initial assessment process.[36] Of these, 447 were deemed irrelevant based on their titles and abstracts. We further narrowed the pool down to relevant articles for comprehensive text review (Appendix Table 1; find all appendix items at the end of the article). Ultimately, 15 publications were selected for inclusion, all of which were RCTs. The PRISMA flow diagram depicts the selection process (Fig 1).

Characteristics of the studies

Details about the included studies are summarized in Table 1. Though all included studies were RCTs, these varied in their design approaches and settings. All studies except for one were conducted in a university setting.[37] In addition, all studies except for one were conducted at a single site[38] in Belgium, Brazil, Greece, Italy, Netherlands, Saudi Arabia, South Korea, or Sweden. Note that all studies were conducted between 2007 and 2021. The duration of follow-up included 3 months,[39] 6 months,[40–45] 12 months,[17,37,38,46-48] 36 months,[20,49] and 60 months.[49]

Definition of disease

The definition of peri-implantitis varied across the studies. However, as per our inclusion criteria, studies used either the 2017 World Workshop classification or a combination of clinical and radiographic criteria. Two studies used the 2017 World Workshop classification.[37,38] Six studies defined peri-implantitis as BoP or SUP on probing with PPD ≥ 5 mm and radiographic evidence of ≥ 2 mm of bone loss .[17,39-41,46,47] Three studies defined peri-implantitis as PPD ≥ 6 mm in at least one aspect of the implant, with BoP and SUP on probing and radiographically documented marginal bone loss > 3 mm.[42,45,48] Hallström et al[20] defined peri-implantitis as ≥ 2 mm of bone loss as determined from a comparison of the bone level 1 year following implant reconstruction or as ≥ 3 mm in depth determined from radiographs in combination with a PPD of ≥ 5 mm and the presence of BoP or SUP on probing.[20] Bombeccari et al[44] used PPD ≥

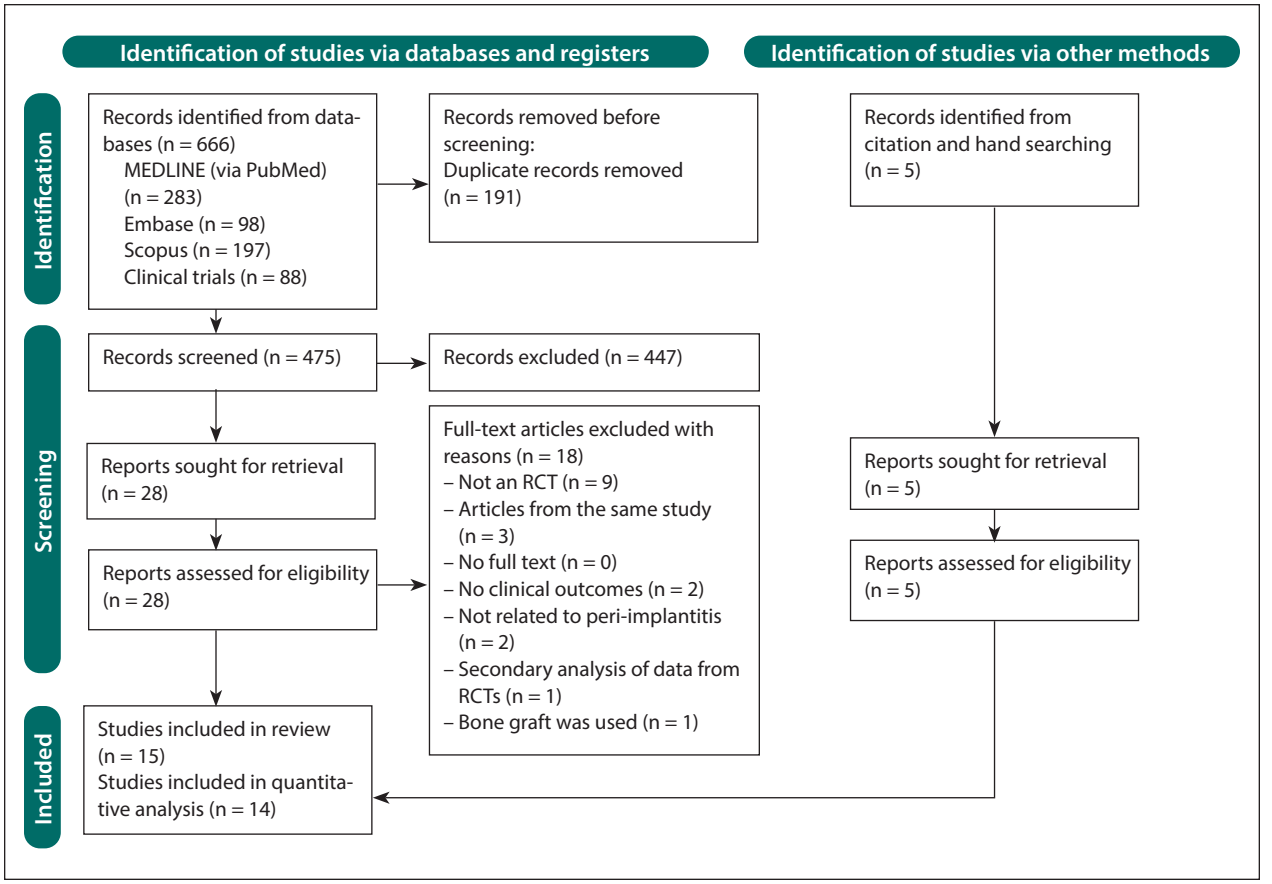

Fig 1 PRISMA flow diagram.

5 mm with BoP and/or inflammatory exudate and concomitant radiographic signs of progressive bone loss (> 3 threads) for a dental implant at least 12 months in function. Lastly, Isehed et al[49] defined peri-implantitis as a PPD ≥ 5 mm with BoP and SUP on probing in addition to an angular peri-implant bone loss of ≥ 3 mm measured radiographically.

Additional study details

Two studies were industry funded,[41,45] and one study did not mention its funding source.[42] The funding source for the other 12 studies was internal from academic or national organizations. The RCTs reported recruiting between 16 to 32 patients. Only studies by Lasserre et al,[41] Fragkioudakis et al,[43] Cha et al,[45] completely excluded smokers.

Implant site and surgical site specifics

All studies reported performing nonsurgical therapy prior to surgical intervention except for one.[37] Eight studies reported that periodontal disease had been previously present at the implant site.[17,20,39,40,45–48] Wagner et al[38] was the only study that did not perform implant surface detoxification. One RCT reported performing implantoplasty as part of the surgical therapy.[41] Albaker et al,[37] Cha et al,[45] and Hallström et al[20] prescribed presurgical and postoperative antibiotics.

Bias Assessment in Studies

The risk of bias was assessed in the included studies and is detailed in Fig 2. Nine of the studies were considered to have a low risk of bias,[12,17,20,39–41,43,45] while two studies[42,49] were seen as having a high risk of bias, primarily due to inconsistent reporting of results. Other studies were deemed to have a moderate risk of bias due to inconsistent reporting of results or bias in their selection.

Assessment of Outcomes

The outcomes and interventions in the included studies are detailed in Table 1. All studies reported changes in PPD and BoP. Additional variables reported included MBL, as determined radiographically, and implant loss. Six studies reported composite outcomes defined as treatment success.[20,40,41,45,47,48] Only one study, Hallström et al,[20] used two composite outcomes and reported treatment success accordingly. All composite outcomes comprised PPD, progressive radiographic bone loss, BoP, and SUP. Only Lasserre et al [41] defined success as a mean PPD reduction of ≥ 0.5 mm with no further bone loss. Outcomes were reported for 3, 6, 12,

24, and 36 months, but only those at 3, 6, and 12 months could be analyzed due to sample size constraints for the 36-month follow-up.

Flap surgery versus osseous resective surgery for treatment of peri-implantitis

Primary outcome: Reduction in PPD

When subgrouping by time point of observation, the estimated mean PPD reduction for the flap group at 3 months was 1.56 mm (95% CI: –0.13–3.25), with a high level of heterogeneity (I^2 = 99.5%). The estimated mean PPD reduction for the osseous group at 3 months was 1.52 mm (95% CI: 1.25–1.79), with high heterogeneity (I^2 = 86.9%). When both groups (flap versus osseous) were compared, no differences were found due to the type of surgery (*P* = .967).

At 6 months, the mean PPD reduction for the flap group was 1.72 mm (95% CI: 0.88–2.55), with a high level of heterogeneity (I^2 = 99.4%). The estimated mean PPD reduction for the osseous group was 1.81 mm (95% CI: 1.14–3.47), with a high level of heterogeneity (I^2 = 98.5%). When both groups were compared, no differences were found due to the type of surgery (*P* = .891).

The highest PPD reduction in the osseous group at 6 months was 2.66 mm, as reported by Carcuac et al,[48] and 3.64 mm for the flap group as reported by Lasserre et al.[41]

At 12 months, the mean PPD reduction for the flap group was 1.27 mm (95% CI: 0.67–1.87), with a high level of heterogeneity (I^2 = 95.9%). The estimated mean PPD reduction for the osseous group was 1.88 mm (95% CI: 1.39–2.37), with a high level of heterogeneity (I^2 = 97.1%). When both groups were compared, no differences were found (*P* = .119).

At 12 months, the highest PPD reduction in the osseous group was 2.52 mm as reported by Carcuac et al,[48] and for the flap group, it was 1.62 mm as reported by Hallström et al[20] (Fig 3) (Appendix Figs 1 and 2, available at the end of the article).

In short, PPD reduction in the flap group was significant at 6 and 12 months (*P* < .001), whereas PPD reduction in the osseous group was significant at 3, 6, and 12 months (*P* < .001). There were no significant differences between the techniques at 3 months (*P* = .967), 6 months (*P* = .891), or 12 months (*P* = .119).

Primary outcome: Reduction in BoP

The estimated mean BoP reduction for the flap group at 3 months was 26.4% (95% CI: –21.9–74.7), with a high level of heterogeneity (I^2 = 99.2%). The estimated mean BoP reduction for the osseous group was 16.8% (95% CI: 2.53–31.1), with high heterogeneity (I^2 = 99.2%). When both groups were compared, no differences were found (*P* = .692). At 6 months, the mean BoP reduction for the flap group was 38.1% (95% CI: 19.9–56.3), with a high level of heterogeneity (I^2 = 99.3%). The mean BoP reduction for the osseous group was 22.4% (95% CI: 0.03–44.8), with a high level of heterogeneity (I^2 = 96.5%). When both groups were compared, no differences were found (*P* = .312). At 12 months, the mean BoP reduction for the flap group was 7.38% (95% CI: –7.21 21.9), with a high level of heterogeneity (I^2 = 97.1%). The mean BoP reduction for the osseous group was 18.9% (95% CI: –2.06–39.9), with a high level of heterogeneity (I^2 = 96.1%). When both groups were compared, no differences were found (*P* = .363) (Fig 4). In short, there were no differences between both techniques at 3, 6, or 12 months (P = .692, .312, and .363, respectively).

Secondary outcome: Changes in radiographic MBLs

No regression model was estimated for 3-month follow-up studies due to both the lack of information reported and the lack of sufficient studies reporting this outcome at this time point.

The estimated MBL for the flap group at 6 months was 0.46 mm (95% CI: –0.04–0.95), with a high level of heterogeneity (I^2 = 95.8%). The estimated mean MBL for the osseous group was –0.14 mm (95% CI: –0.27–0.02), with a low level of heterogeneity (I^2 = 24.9%). When flap and osseous groups were compared, significantly more bone loss (0.58 mm more) was found for the osseous group (*P* = .044). At 12 months, mean MBL change in the flap group was 0.66 mm (95% CI: 0.46–0.87), with a moderate level of heterogeneity (I^2 = 65.4%). The mean MBL change for the osseous group was –0.07 mm (95% CI: –0.31–0.17), with a high level of heterogeneity (I^2 = 76.8%). When the flap and osseous groups were compared, significantly more bone loss (0.73 mm) was found in the osseous group (*P* = .001) (Fig 5; Appendix Figs 3 and 4, available at the end of the article).

In summary, the marginal bone loss at 6 months was significantly higher in osseous surgery—with a difference of 0.58 mm—compared to flap surgery (P = .044). The same result was observed at 12 months (0.73 mm; P < .001).

Secondary outcome: Reduction in PI

The estimated mean PI reduction for the flap group at 3 months was 0.48% (95% CI: –8.37–9.33), with a high level of heterogeneity (I^2 = 92.9%). The estimated mean PI reduction for the osseous group was 2.12% (95% CI: –6.63–10.9), with high heterogeneity (I^2 = 89.5%). When both groups were compared, no differences were found (*P* =.793). No regression model was estimated for 6- and 12-month follow-up studies due to the insufficient information reported by an adequate number of studies at these time points.

Table 1 Included Study Characteristics

Authors	Year	No. of centers	Country	Study setting	Total patients	Peri-implantitis definition	Treatment groups	No. of participants	No. of implants	Female participants (%/N)	Male participants (%/N)	Age of participants (mean ± SD)	Medical conditions (Y/N)	Diabetic patients, %
Albaker et al	2018	1	Saudi Arabia	Private practice	24	Marginal bone loss ≥ 2 mm after 1 y of loading or ≥ 3 mm in new radiographs	Access flap: AB + AS	13	13	31%	69%	61.5 ± 9.9	Y	15%
							Access flap: AB + AS Antimicrobial photodynamic therapy	11	11	18%	82%	58.4 ± 8.0	Y	36%
Wagner et al	2021	2	Brazil	University	45	PPD ≥ 5 mm with BoP and radiographic evidence of bone loss ≥ 2 mm	Flap surgical treatments	24	30	18	6	60.1 ± 8.6	N	None
Lasserre et al	2020	1	Belgium	University	31	Peri-implant PPD ≥ 5 mm, marginal bone loss ≥ 2 mm, and BoP and/or SUP	Implantoplasty	Test group = 16	22	11	5	62.3	N	None
							Glycine air polishing	Control group = 15	20	11	4	71	N	None
Hallström et al	2017	1	Italy	University	39	According to the Albrektsson et al (1986) and Roos et al (1997) criteria, such as absence of progressive marginal bone loss (bone resorption in measurement areas not greater than 1 mm during the first year of implant positioning and 0.2 mm per year in subsequent years)	Resective surgery and implantoplasty	15	20	75%	25%	68.8 ± 25.0	Y	NR
							Resective surgery only	16	18	63%	37%	71 ± 7.7	Y	NR
de Waal et al	2013	1	Netherlands	University	30	Peri-implant PPD ≥ 5 mm and bone loss ≥ 2 mm	A placebo solution	– 15	– 48	10	5	61.5 (10.0)	N	None
de Waal et al	2014	1	Netherlands	University	22	BoP and/or SUP, peri-implant PPD ≥ 5 mm and bone loss ≥ 2 mm	Rinsed for 1 min with a 2% CHX solution (alcohol-based) (test group)	22	49	17	5	58.6 (10.2)	N	None
					22		0.12% CHX + 0.05% CPC without alcohol	22	59	14	8	60.5 (11.6)	N	None

Smoking status / systemic diseases	History of periodontitis	Previous periodontal disease at implant site	Was NST performed before surgery? (Y/N)	Single or multiple treated sites	Site (arch)	Type of intervention	Implantoplasty (Y/N)	Implant surface decontamination (Y/N)	Method of decontamination	Implant system/ implant surface	Preoperative antibiotics and dosage (Y/N)	Type of prosthesis	Removed before surgery (Y/N)
Y	NR	NR	NR	Single	NR	Flap	N	Y	Titanium curettes and gauze	NR	NR	NR	NR
Y	NR	NR	NR	Single	NR	Flap	N	Y	Titanium curettes and gauze + one session of antimicrobial photodynamic therapy post surgery	NR	NR	NR	NR
Y	Y	NR	Y	Multiple	Both	Flap	N	N	NR	NA	NR	SR = 14, C = 10	Y (only for screw retained)
Nonsmokers	Y	–	Y	Single	Both	Flap	Y	Y	Round diamond burs	A modified implant surface: rough (titanium plasma-sprayed; 16.7%) and microrough (83.3%)	NR	SR = 1, C = 18	–
Nonsmokers	Y	–	Y	Single	Both	Flap	N	Y	Air-Flow Handy 3.0 Perio, EMS		NR	SR = 1, C =13	–
Y	Y	47%	Y	Multiple	NR	Flap	N	Y	Plastic scaler	–	–	Both	NR
Y	Y	53%	Y	Multiple	NR	Flap	N	Y		–	–	Both	NR
Y	Y	5 (33.3)%	Y	Multiple	Maxilla: 24 (50.0)% Mandible: 11 (35.5)%	Osseous	N	Y	A placebo solution	NA	N	Both	Y
Both	Y	10 (45.5)%	Y	Multiple	Both	Osseous	N	Y	Curette and 2% CHX solution (alcohol-based)	Multiple implant system	–	SR = 45 (91.8) CR = 4 (8.2)	Y
Both	Y	10 (45.5)%	Y	Multiple	Both	Osseous	N	Y		Multiple implant system	–	SR = 42 (71.2) CR = 17 (28.8)	Y

Table 1 *(cont)* **Included Study Characteristics**

Authors	Year	No. of centers	Country	Study setting	Total patients	Peri-implantitis definition	Treatment groups	No. of participants	No. of implants	Female participants (%/N)	Male participants (%/N)	Age of participants (mean ± SD)	Medical conditions (Y/N)	Diabetic patients, %
Hentenaar et al	2021	1	Netherlands	University	58	PPD ≥ 5 mm with concomitant BoP and/or SUP and progressive loss of marginal bone ≥ 2 mm	Airflow, using the Airflow Master Piezon device, EMS) with erythritol-based powder containing 0.3% CHX (14 µm, PLUS Powder, EMS)	27	54	33	25	58.9 ± 11.7	Y	3.7% / 1 patient
							Implant surface was mechanically cleaned with saline-soaked cotton gauzes	31	40				Y	3.2% / 1 patient
Isehed et al	2018	1	Sweden	University	29	PPD ≥ 5 mm and BoP and/or SUP and at least one implant with angular peri-implant bone loss ≥ 3 mm measured on radiograph	Surgical treatment with adjunctive EMD	15	15	NA	NA	70	Y	NR
							No EMD	14	14	NA	NA	70	Y	NR
Toma et al	2019	1	Belgium	University	47	BoP or SUP , PPD ≥ 5 mm, complete immobility of the implant, radiographic evidence of bone loss ≥ 2 mm or resulting in exposure of two or more implant threads for systems with visible implant threads	Plastic curettes	15	25	77%	23%	68.9 ± 15.8	N	None
							An air-abrasive device (Perio-Flow)	16	22	90%	10%	67.5 ± 12.9	N	None
							A titanium brush (Ti-Brush)	16	23	81%	19%	61.7 ± 13.4	N	None
Papadopoulos et al	2015	1	Greece	University	19	PPD ≥ 6 mm in at least one implant and the simultaneous presence of BoP or SUP, no mobility of the implant, radiographic bone loss ≥ 2 mm at 1+ implant surface	Flap + laser	8	8	10	6	55 ± 8.7	Y	NR
							Flap only	8	8			55 ± 8.7	Y	NR
Fragkioudakis et al	2023	1	Greece	University	20	2017 World Workshop on Periodontology definition	Flap + laser	10	10	5	5	58.10 ± 8.54	N	None
							Flap only	10	10	4	6	60.28 ± 6.34	N	None
Carcuac et al	2016	1	Sweden	University	100	PPD and BoP or SUP at four aspects per implant	Group 1: AB+/AS+	27	47	20	7	65.7 (23–90)	Y	7.4% / 2 patients
							Group 2: AB+/AS–	25	46	17	8	67.9 (21–88)	Y	None
							Group 3: AB–/AS+	24	49	14	10	64.6 (27–81)	Y	4.2% / 1 patient
							Group 4: AB–/AS–	24	37	14	10	66.9 (30–88)	Y	8.3%/ 2 patients
Hentenaar et al	2017	1	Netherlands	University	14	Loss of marginal bone ≥ 2 mm in combination with BoP and/or SUP and a peri-implant probing depth ≥ 5 mm	Flap + 35% phosphoric etching gel	14	22	7	7	60.9 (7.2)	N	None
					14		Flap + saline	14	31	9	5	57.0 (13.7)	N	None

Smoking status / systemic diseases	History of periodontitis	Previous periodontal disease at implant site	Was NST performed before surgery? (Y/N)	Single or multiple treated sites	Site (arch)	Type of intervention	Implantoplasty (Y/N)	Implant surface decontamination (Y/N)	Method of decontamination	Implant system/ implant surface	Preoperative antibiotics and dosage (Y/N)	Type of prosthesis	Removed before surgery (Y/N)
Y	y	9 (33.3)%	y	Multiple	Both	Flap	N	Y	Airflow with erythritol-based powder containing 0.3% CHX	SLA + SLA active, TiUnite, Other (Osseotite, Osseospeed, Xspeed, machined/ turned, and plasma-sprayed HA	–	SR = 38 (70.4) C = 16 (29.6)	Y
Y	y	12 (38.7)%	y	Multiple	Both	Flap	N	Y	Saline-soaked cotton gauzes		–	SR = 28 (70.0) C = 12 (30.0)	Y
Y	NA	–	Y	Single	–	Flap	N	Y	Ultrasonic cleaner with a special implant tip and titanium instruments combined with rinsing with sodium chloride solution (9 mg/mL, 2 × 20 mL)	Modified	–	NA	–
Y	NA	–	Y	Single	–	Flap	N	Y		Modified	–	NA	–
NR	Y	84%	Y	Multiple	–	Flap	N	Y		Microroughened surface 80.8%	–	Both	N
NR	Y	73%	Y	Multiple	–	Flap	N	Y		Microroughened surface 78.9%	–	Both	N
NR	Y	82%	Y	Multiple	–	Flap	N	Y	Gracey curette + sodium chloride	Microroughened surface 86.3%	–	Both	N
NA	NA	–	Y	Single	–	Flap	N	Y		NA	–	NA	N
NA	NA	–	Y	Single	–	Flap	N	Y	Ultrasonics and hand instruments	NA	–	NA	N
N	NA	–	Y	Single	–	Flap	N	Y	Titanium implant scalers + sterilized gauze soaked in 0.2% CHX solution	–	–	NA	Y
N	NA	–	Y	Single	–	Flap	N	Y		–	–	NA	Y
Y	Y	21 (77.8)%	Y	Multiple	Both	Osseous	N	Y	10 × 10–mm gauze soaked in 0.2% CHX	Modified	Y	SR	Y
Y	Y	21 (84)%	Y	Multiple	Both	Osseous	N	Y	Saline solution	Modified	Y	SR	Y
Y	Y	21 (87.5)%	Y	Multiple	Both	Osseous	N	Y	10 × 10–mm gauze soaked in 0.2% CHX	Modified	Y	SR	Y
Y	Y	21 (87.5)%	Y	Multiple	Both	Osseous	N	Y	Saline solution	Modified	Y	SR	Y
Y	Y	5 (36%)	Y	Single	–	Flap	N	Y	35% phosphoric etching gel	Modified	N	NA	Y (only for screw retained)
Y	Y	4 (29%)	Y	Single	–	Flap	N	Y	Saline solution	Modified	N	NA	Y (only for screw retained)

Table 1 *(cont)* **Included Study Characteristics**

Authors	Year	No. of centers	Country	Study setting	Total patients	Peri-implantitis definition	Treatment groups	No. of participants	No. of implants	Female participants (%/N)	Male participants (%/N)	Age of participants (mean ± SD)	Medical conditions (Y/N)	Diabetic patients, %
Cha et al	2019	1	South Korea	University	25	Peri-implant bone loss > 2 mm, PPD > 5 mm, and concomitant BoP with no history of surgical treatment for peri-implantitis	Sites treated by open-flap debridement combined with minocycline ointment	25	25	15	10	63.0 (46–84)	N	None
				University	25			25	25	10	15	60.2 (40–83)	N	None
Bombeccari et al	2013	1	Italy	University	24	PPD ≥ 5 mm, with the presence of BoP and/or inflammatory exudation; patients also had concomitant radiographic signs of progressive bone loss (bone loss .3 threads) around the dental implant for at least 12 months	Flap + PDT group	NA	NA	NA	NA	46	N	None
					16		Flap + conventional therapy	NA	NA	NA	NA	46	N	None

Note that all studies were randomized controlled studies, and none of the implants were tissue-level implants.
SR = screw retained; C = cement; PPD = probing pocket depth; BoP = bleeding on probing; SUP = suppuration on probing; CHX = chlorhexidine; EMD = enamel matrix derivative; NR = not reported; NA = not available; NST = nonsurgical treatment.

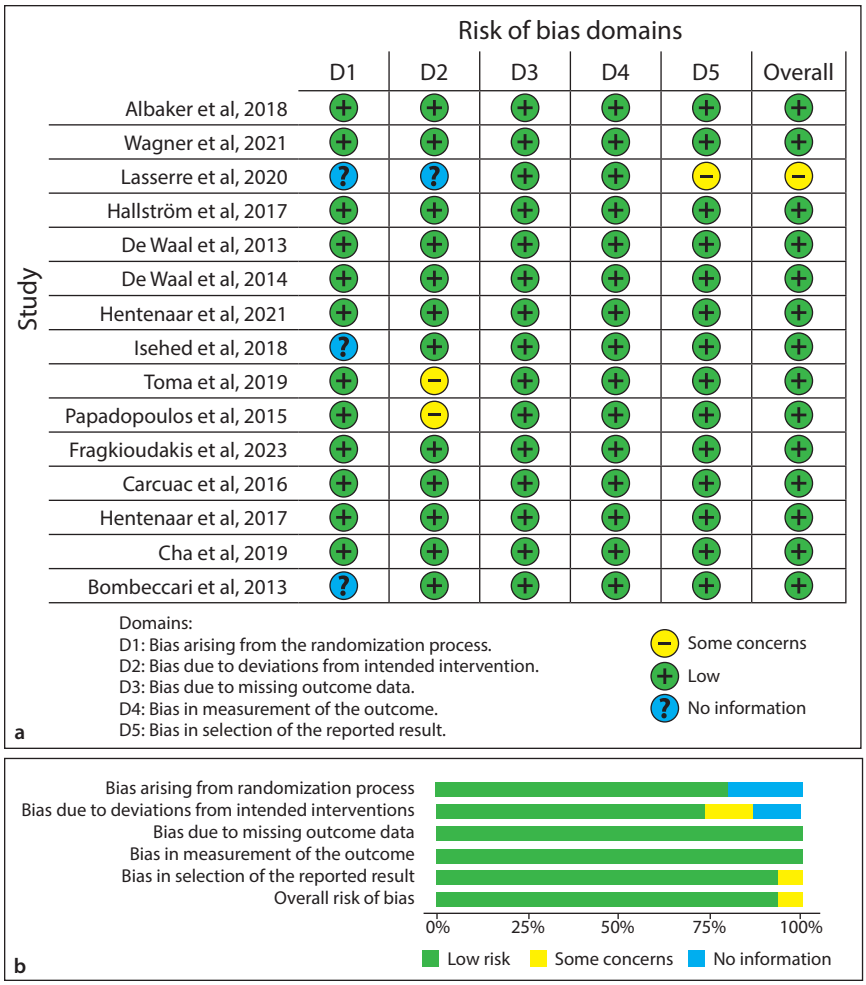

Fig 2 *(a)* Details of risk-of-bias assessment performed for randomized controlled trials answering FQ1 with RoB2. *(b)* Overall details of risk-of-bias assessment.

Smoking status / systemic diseases	History of periodontitis	Previous periodontal disease at implant site	Was NST performed before surgery? (Y/N)	Single or multiple treated sites	Site (arch)	Type of intervention	Implantoplasty (Y/N)	Implant surface decontamination (Y/N)	Method of decontamination	Implant system/ implant surface	Preoperative antibiotics and dosage (Y/N)	Type of prosthesis	Removed before surgery (Y/N)
N	Y	22 (88.0)%	Y	Both	–	Flap	N	Y	Titanium-coated curettes, a metallic copper-alloy ultrasonic scaler tip, a titanium brush, and an air-powder abrasion device	Modified	–	NA	N
N	Y	20 (80.0)%	Y	Both	–	Flap	N	Y		Modified	–	NA	N
Y	Y	–	Y	Single	––	Flap	N	Y		Modified	–	NA	N
Y	Y	–	Y	Single	–	Flap	N	Y	Plastic scalers and irrigation with 0.2% CHX solution for 1 min before treatment	Modified	–	NA	N

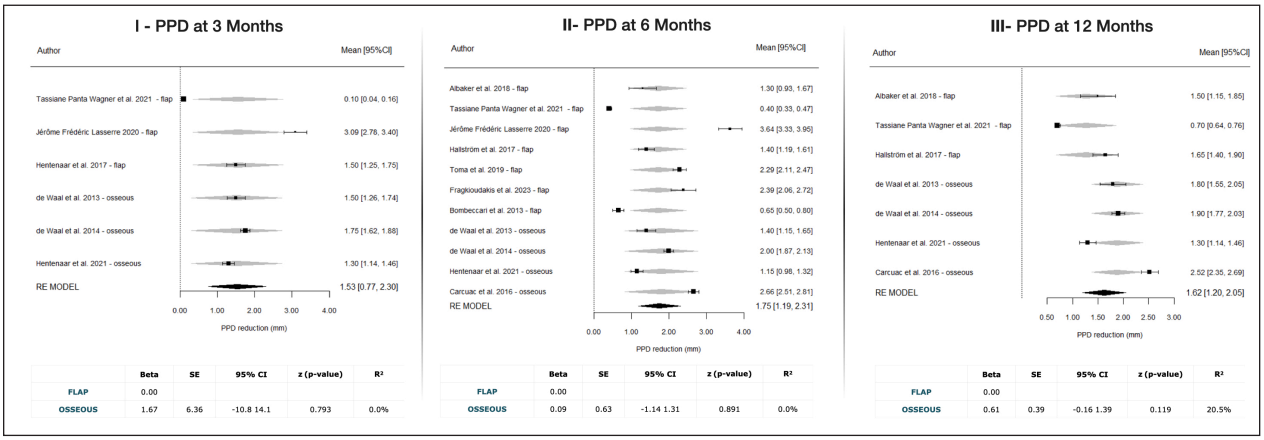

Fig 3 Forest plot illustrating reduction of mean PPD.

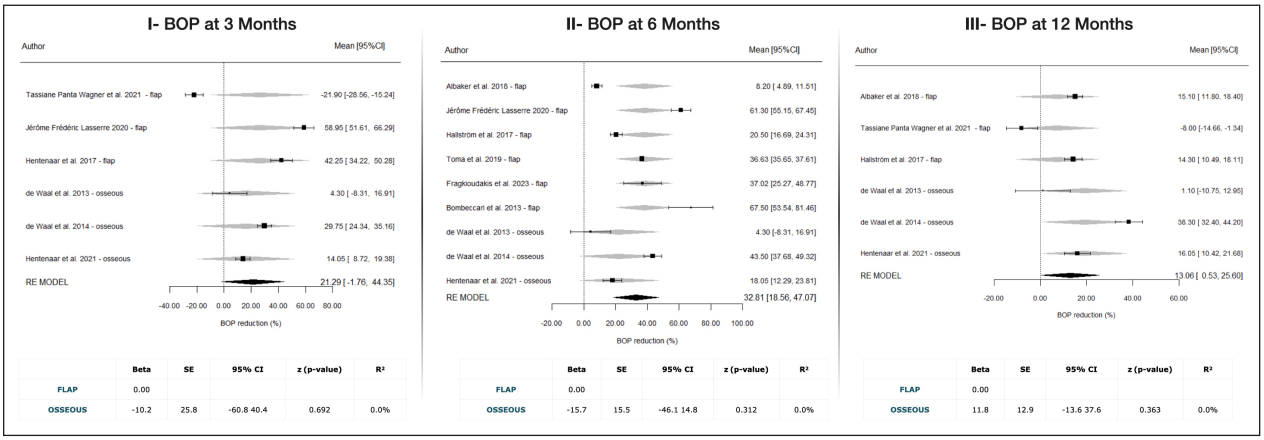

Fig 4 Forest plot illustrating reduction of mean BoP.

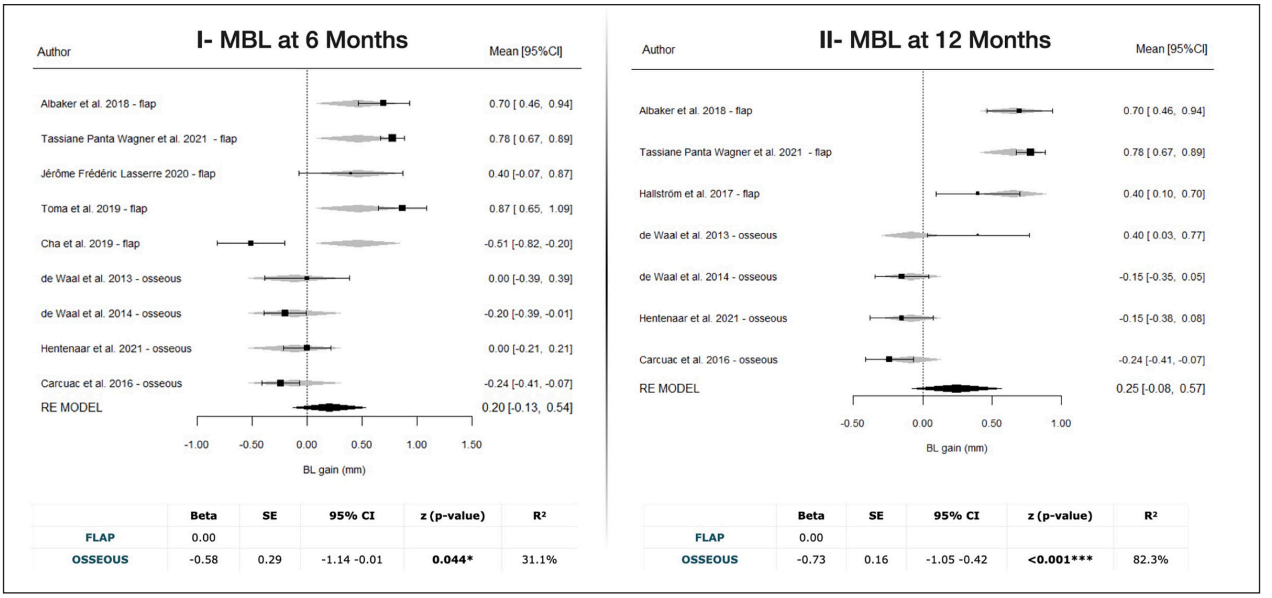

Fig 5 Forest plot illustrating radiographic MBL changes.

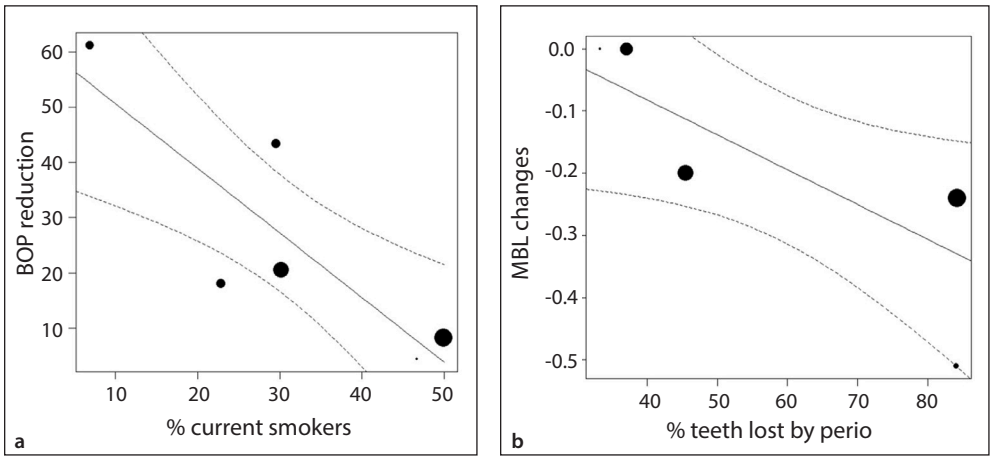

Fig 6 Inverse relationship between *(a)* BoP reduction and the percentage of smokers per cohort, and *(b)* MBL changes and history of periodontitis.

Secondary outcome: Effect of covariates

Results of meta-regression of PPD and BoP reduction and MBL changes were assessed at 6 months (results at 12 months could not be assessed due to sample size restrictions).

For PPD, there were no differences in the results due to sex ($P = .469$), age ($P = .173$), or the proportion of current light smokers ($P = .734$).

For BoP, there were also no differences in the results due to sex ($P = .200$) or age ($P = .506$). On the other hand, differences were reported related to the proportion of current smokers ($P = .002$). For each additional 1% in the rate of current smokers, BoP reduction was lower (–1.17%) (Fig 6a).

For MBL changes, there were no differences in the results due to sex ($P = .574$), age ($P = .769$), or the proportion of current light smokers ($P = .525$). Previous severity of periodontitis on implant sites was detected as a significant covariate ($P = .043$), but it was not clinically significant. Note that for each additional 1% of bone loss due to periodontitis, 0.006 mm more marginal bone loss occurred (Fig 6b).

Quality of Evidence

After using GRADE (Appendix Fig 5, available at the end of this article), it was determined that both types of surgery were equally effective in reducing PPD, with moderate quality. The reason for downgrading the quality of evidence was because of the indirectness in the comparison and the heterogenicity of the results. High-quality evidence shows that flap surgeries may provide a slight advantage in maintaining MBLs compared to osseous resective surgery. Although the indirectness was serious, a large-enough sample size and narrow CIs prevented downgrading (Appendix Fig 6, available at the end of this article).

DISCUSSION

In this systematic review, the outcomes of nonreconstructive surgical treatments—such as access flap or pocket-elimination techniques—compared to osseous resection for the treatment of peri-implantitis sites were assessed. The analysis revealed no significant differences when comparing both groups in terms of PPD or BoP. The only distinction observed was in MBLs, which favored the flap group. The flap group exhibited a slight increase in MBLs, whereas the osseous group showed a slight decrease in MBLs. The MBL difference was 0.58 mm after 6 months in favor of flap surgery ($P = .044$). The trend persisted at 12 months with a 0.73-mm difference favoring flap surgery ($P < .001$). This difference in MBL between flap and osseous resective surgeries may relate to the goal of achieving favorable soft and hard tissue architecture by eliminating what are deemed "unfavorable deformities," such as a shallow crater defect, not necessarily due to ongoing disease.

Despite the absence of direct comparative studies between these techniques, both methods provided significant improvements in the key outcomes across 15 prospective cohort studies. These improvements included notable reductions in PPD and BoP and minimal changes in MBL over periods ranging from 3 to 12 months. However, it is critical to note that considerable heterogeneity was evident in almost all results.

Assessing non-reconstructive surgical treatment of periimplantitis to non-surgical therapy is a common comparison.[50,51] That said, its appropriateness can be debated since clinicians generally follow a progressive treatment strategy in line with the current EFP guidelines.[50]

All studies included in the present network meta-analysis reported performing nonsurgical therapy before the surgical intervention was performed, except the study by Albaker et al.[37] In addition, the case definitions of peri-implantitis in the present review are either similar or of more stringent criteria than those suggested (see Table 1). The European Federation of Periodontology guideline recommends performing access flap or resective surgery, as both modalities are effective.[50] However, no present literature has systematically compared both modalities except the recent meta-analysis by Karlsson et al[51] that investigated studies comparing access flap or pocket-elimination procedures to nonsurgical therapy at peri-implantitis sites. Karlsson et al[51] reported a significant reduction in clinical signs of inflammation concomitant with stable MBLs up to 5 years after surgical therapy; however, they could not base their results on direct comparisons due to a lack of literature. Our review contextualizes the effectiveness of both nonreconstructive (flap or osseous) surgical interventions for treating peri-implantitis because both modalities significantly reduced PPD and BoP and largely maintained MBLs (see Figs 1 to 3).

The present authors recognize that surgical interventions yield superior outcomes relative to nonsurgical approaches when treating peri-implantitis,[7,8,51] and we also further acknowledge that the present study failed to accumulate enough evidence of a difference between both treatments; however, this naturally leads to an intriguing question: Does reconstructive surgical therapy offer enhanced outcomes compared to nonreconstructive techniques? Addressing this query is the focal point of another systematic review in this series. Nonetheless, a recent systematic review and meta-analysis by Donos et al[52] demonstrated that reconstructive surgery for treating peri-implantitis does not yield significant improvements in peri-implant clinical parameters compared to flap surgery at 12 months. Other reviews have reported increased bone fill with reconstructive techniques with[14] or without[23] significant change in other clinical parameters, which may suggest better implant survival.[53,54] Nonetheless, the improvement in MBLs using reconstructive techniques, as reported by Tomasi et al,[23] was 1.7 mm compared to approximately 0.7 mm using flap surgery in the present review. The clinical relevance of this 1-mm difference is contingent upon the specific clinical scenario at hand.

Methodologic variations among studies included in the present review may significantly impact the interpretation of its outcomes. Moreover, pretreatment PPD values and their subsequent reduction may play an important role.[50] Different studies employed various approaches for measuring PPD, with some selecting the deepest site to represent the entire implant,[48] while others averaged across multiple sites.[46] This distinction can have a substantial impact on outcomes.

Multiple studies in this review prescribed preoperative and postoperative antibiotics.[20,37,45] The role of systemic antibiotic treatments in surgery should ideally be assessed in RCTs. The lack of studies focusing on the exclusive use of systemic antimicrobials renders their actual impact on treatment outcomes unclear.

Current evidence provided by Teughels et al[55] indicated that although systemic antimicrobials had a positive impact on MBL, only 50% of the cases achieved disease resolution after 1 year.

Other potential confounding factors and mathematical coupling risks[8] limit definitive conclusions. Our review faced constraints due to limited sample sizes in certain meta-regression models, thereby potentially rendering the findings in specific analyses less reliable. A high level of heterogeneity was observed across the studies included. This variability, reflected in high I^2 values, shows that the study results may be influenced by different study designs, patient populations, and treatment protocols, which could affect the generalizability

of the findings. Potential publication bias was another limitation, as indicated by significant results in Egger's tests in some analyses (see Fig 4). This suggests that the available literature might disproportionately represent studies with positive findings, skewing the conclusions of the present review. These findings underscore the need for further research, particularly well-designed studies directly comparing different surgical interventions for peri-implantitis treatment.

CONCLUSIONS

- Studies directly comparing nonreconstructive flap surgery and osseous resective surgery for peri-implantitis sites are lacking. Future two-arm RCTs should directly compare both treatments to test for superiority. Variables like defect morphology and classification should be considered. In addition, diagnostic modalities like CBCT should be considered to measure treatment outcomes.
- Both nonreconstructive surgical interventions are effective in managing peri-implantitis. They both exhibit improvements in relevant clinical parameters such as PPD and BoP.
- The observed MBL changes slightly favor flap surgery.
- A weak inverse relationship between BoP reduction and smoking was observed.
- Slightly more marginal bone loss was observed in patients with a history of periodontitis.

ACKNOWLEDGMENTS

Dr Tara Aghaloo, Dr Joseph P. Fiorellini (group co-chair), Dr Paul Rosen, and Dr Hom-Lay Wang (consensus co-chair) have thoroughly reviewed the paper and provided valuable comments. The authors do not have any financial interests, either directly or indirectly, in the products or information listed in the paper. Original raw data collected is available from the corresponding author upon request.

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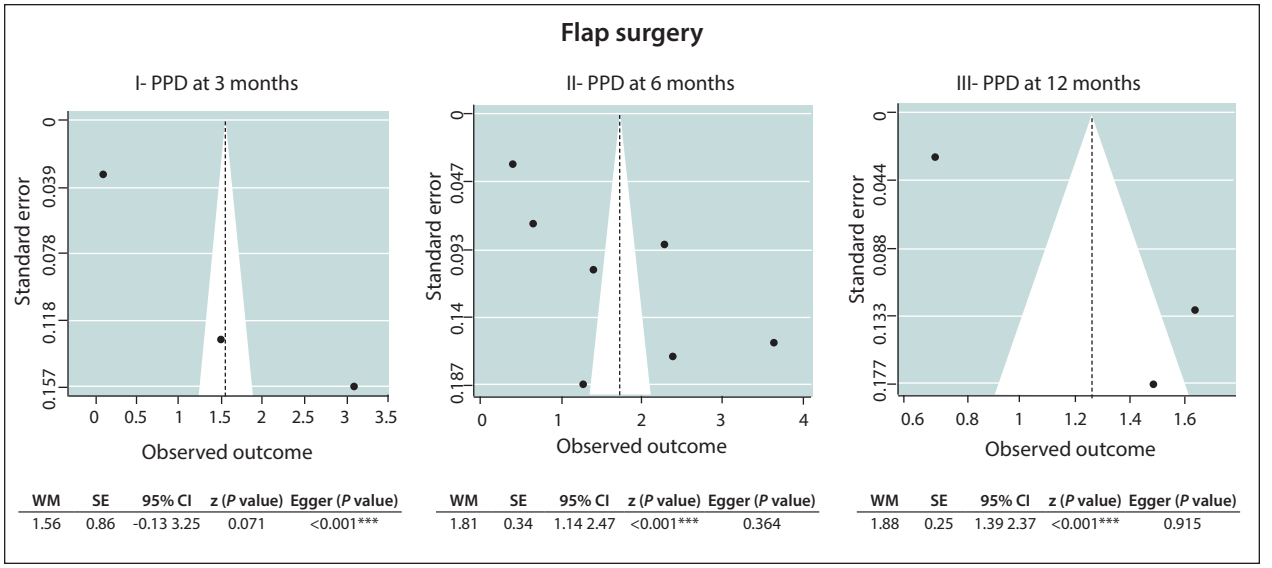
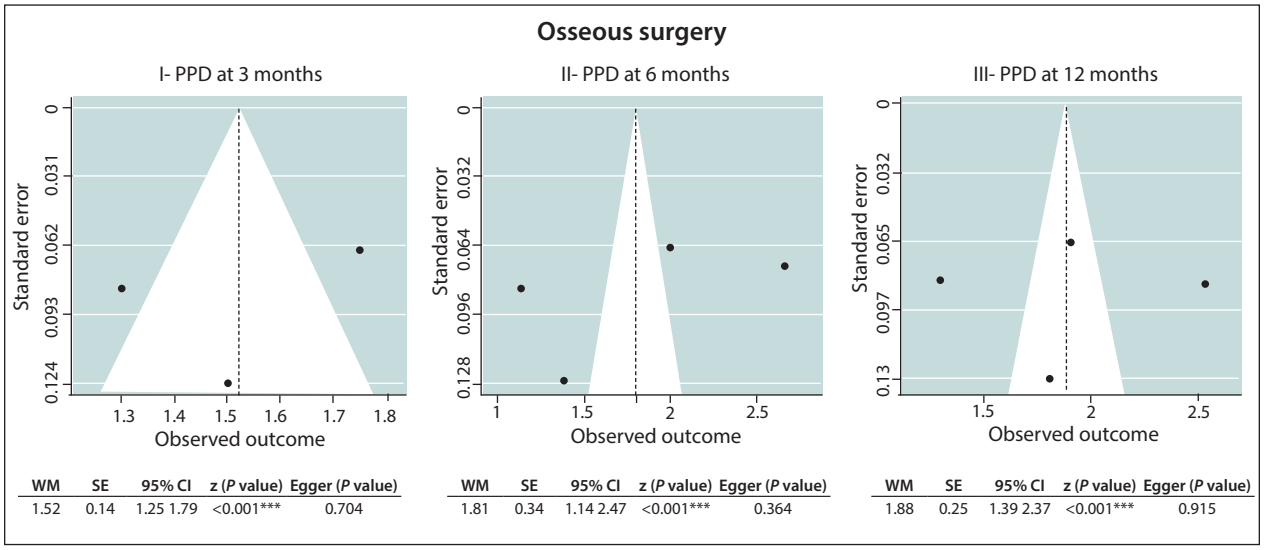
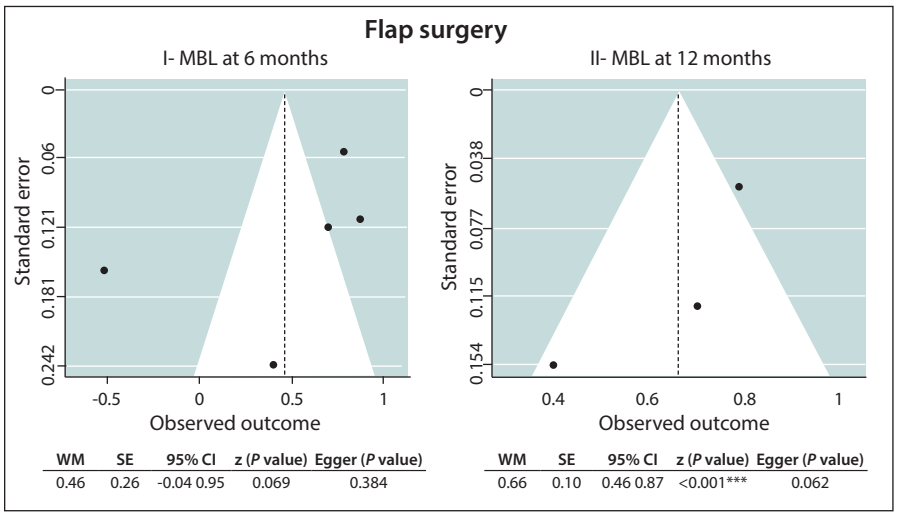
APPENDIX



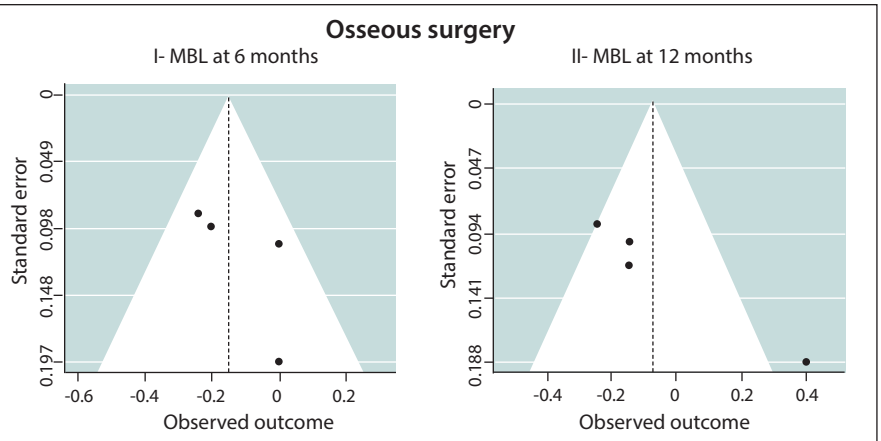
Appendix Fig 1 Egger's test funnel graphs showing the potential publication bias when the efficacy of the flap group was assessed for PPD.



Appendix Fig 2 Egger's test funnel graphs showing the potential publication bias when the efficacy of the osseous group was assessed for PPD.



Appendix Fig 3 Egger's test funnel graphs showing the potential publication bias for when the efficacy of the flap group was assessed for MBL changes.



WM	SE	95% CI	z (*P* value)	Egger (*P* value)
-0.14	0.06	-0.27 -0.02	0.026*	0.209

WM	SE	95% CI	z (*P* value)	Egger (*P* value)
-0.07	0.12	-0.31 0.17	0.539	<0.001***

Appendix Fig 4 Egger's test funnel graphs showing the potential publication bias for when the efficacy of the osseous group was assessed for MBL changes.

Flap compared to Osseous surgery for Treatment of Peri-implantitis

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Flap	Osseous surgery	Relative (95% CI)	Absolute (95% CI)	
PPD Reduction (follow-up: 6 months)											
11	randomized trials	not serious	serious	serious	not serious	all plausible residual confounding would reduce the demonstrated effect	264	429	-	MD **0.09 lower** (1.31 lower to 1.14 higher)	⊕⊕⊕◯ Moderate
BOP Reduction (follow-up: 6 months; Scale from: 0 to 100)											
9	randomized trials	not serious	serious	serious	serious	all plausible residual confounding would reduce the demonstrated effect	234	250	-	**15.7 higher** (14.8 lower to 46.1 higher)	⊕⊕◯◯ Low
Marginal Bone Changes (follow-up: 6)											
9	randomized trials	not serious	not serious	serious	not serious	all plausible residual confounding would reduce the demonstrated effect	216	429	-	**0.58 higher** (0.01 higher to 1.14 higher)	⊕⊕⊕⊕ High
PPD Reduction (follow-up: 12 months)											
7	randomized trials	not serious	not serious	serious	serious	all plausible residual confounding would reduce the demonstrated effect	92	429	-	**0.61 lower** (1.39 lower to 0.16 higher)	⊕⊕⊕◯ Moderate
BOP Reduction (follow-up: 12 months; Scale from: 0 to 100)											
6	randomized trials	not serious	serious	serious	serious	all plausible residual confounding would reduce the demonstrated effect	92	250	-	**11.8 lower** (37.6 lower to 13.6 higher)	⊕⊕◯◯ Low
Marginal Bone Changes (follow-up: 12 months)											
7	randomized trials	not serious	not serious	serious	not serious	all plausible residual confounding would reduce the demonstrated effect	92	429	-	**0.73 higher** (0.42 higher to 1.05 higher)	⊕⊕⊕⊕ High

CI: confidence interval; **MD:** mean difference

Appendix Fig 5 GRADE table showing the level of evidence quality.

Flap compared to Osseous surgery for Treatment of Peri-implantitis

Patient or population: Peri-implantitis
Intervention: Flap
Comparison: Osseous surgery

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects	
				Risk with Osseous surgery	Risk difference with Flap
PPD Reduction (PPDR) follow-up: 6 months	693 (11 RCTs)	⊕⊕⊕◯ Moderate	-	The mean PPD Reduction was **0**	MD **0.09 lower** (1.31 lower to 1.14 higher)
BOP Reduction (BOPR) Scale from: 0 to 100 follow-up: 6 months	484 (9 RCTs)	⊕⊕◯◯ Low	-	The mean BOP Reduction was **0**	**15.7 higher** (14.8 lower to 46.1 higher)
Marginal Bone Changes (MBC) follow-up: 6	645 (9 RCTs)	⊕⊕⊕⊕ High	-	The mean BL Gain was **0**	**0.58 higher** (0.01 higher to 1.14 higher)
PPD Reduction (PPDR) follow-up: 12 months	521 (7 RCTs)	⊕⊕⊕◯ Moderate	-	The mean PPD Reduction was **0**	**0.61 lower** (1.39 lower to 0.16 higher)
BOP Reduction (BOPR) Scale from: 0 to 100 follow-up: 12 months	342 (6 RCTs)	⊕⊕◯◯ Low	-	The mean BOP Reduction was **0**	**11.8 lower** (37.6 lower to 13.6 higher)
Marginal Bone Changes (MBC) follow-up: 12 months	521 (7 RCTs)	⊕⊕⊕⊕ High	-	The mean Bone Gain was **0**	**+0.73 higher** (0.42 higher to 1.05 higher)

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **MD:** mean difference

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Appendix Fig 6 GRADE table showing the summary of results.