

Impact of Concave/Convergent vs Parallel/Divergent Implant Transmucosal Profiles on Hard and Soft Peri-implant Tissues: A Systematic Review with Meta-Analyses

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Purpose: To systematically review the literature comparing marginal bone loss (MBL) and pink esthetic scores of implants with convergent or concave transmucosal profiles vs divergent or parallel profiles. **Materials and Methods:** A PICO question was defined, and an electronic search was carried out in the MEDLINE/PubMed and Cochrane Oral Health Group databases. Studies documenting type of transmucosal profile (either tissue-level profiles or abutments) and soft and/or hard tissue outcomes of implants were considered eligible. Studies were selected on the basis of the inclusion criteria and quality assessments. A meta-analysis with subgroup analyses was performed. **Results:** Five papers fulfilled the inclusion criteria, and four were eligible for meta-analysis. Significantly less MBL was found in concave/convergent groups, with a mean difference of 0.772 (95% confidence interval [CI]: 0.450 to 1.095; $P < .001$). In the subgroup analyses for platform-switching and platform-matching connections, a significant effect in favor of concave/convergent was detected, with a standardized difference in means of 1.135 (95% CI: 0.688 to 1.583, $P < .001$) when platform switching was considered. No significant effects were found for platform-matching connections. **Conclusion:** Within the limitations of this review, it is suggested that concave/convergent implant transmucosal profiles result in less MBL. No statistically significant results were obtained for soft tissue-related outcomes or for the platform-matching connection subgroup. *Int J Prosthodont* 2020;33:553–564. doi: 10.11607/ijp.6726

When considering successful outcomes of dental implant rehabilitations, osseointegration seems to be the fundamental concept behind their successful functioning and stability. However, it is probably worth asking whether only variables related to the bone should be considered as the basis of osseointegration and not also those related to soft tissues. More specifically, it is interesting to investigate the peri-implant soft tissue components at the microscopic and histologic levels that determine or favor implant success and how they can be modulated.

Implants, even those at bone level, have a component that comes into contact with epithelial and connective (ie, soft) tissues in addition to bone (ie, hard tissue). The interaction between implants and the soft tissue component is of primary importance rather than secondary to the interaction between implants and hard tissue. The maintenance of the health of the peri-implant soft tissue is crucial for implant success and long-term maintenance.

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It is known that, as far as implant platform positions are concerned, there are generally two types of implants: bone level, where the connection between the implant and the prosthetic part is at the level of the bone crest, and tissue level, where the same connection is at the soft-tissue level. At the microscopic level, one difference is the presence/location of bacterial microflora, which normally contaminate the space at the implant-prosthetic connection—which, in the case of bone-level implants, is in closer contact with the bone crest.^{1,2} At the macroscopic level, the differences occur mainly in the design of the emergence profile, which is managed differently because tissue-level implants typically have a divergent profile.

In bone-level implants, the transmucosal component can have two types of connection: platform matching (PM) or platform switching (PS). The PS connection, with its narrower-diameter abutment, transfers the implant-prosthetic microgap, which is the area that can be colonized by bacteria³ and undergoes stronger biomechanical stress,^{4,5} to a more internal level far from the bone crest. Moreover, it is conceivable that PS creates a shift of the peri-implant biologic width (or supracrestal tissue attachment, according to the latest American Academy of Periodontology and European Federation of Periodontology 2017 workshop⁶) to the horizontal plane, providing a flat profile for the formation of peri-implant collagen fibers so that they do not invade the bone-implant interface.⁷ This concept of collagen fiber migration could also lead to the possibility that, if the fibers were induced by the anatomical shape of the peri-implant transgingival profile to position themselves at a more coronal level, this migration could reduce peri-implant bone resorption. This was the goal of introducing abutments with convergent profiles as opposed to the classic divergent ones. In addition to providing the biologic space with a more horizontal housing, a convergent design also provides more space for soft tissues. To better clarify what the present authors intend to define as a concave/convergent abutment (in the case of a bone-level implant) or transmucosal profile (in the case of a tissue-level implant), “concave” is identified as a profile with a curved indentation (or, as it is called by many authors, a “groove”), and “convergent” as a profile with a progressive narrowing of the diameter toward the coronal direction. On the contrary, “parallel” is defined as a profile with the same diameter along its entire height, and “flared” or “divergent” as a profile that is divergent (Fig 1).

The purpose of this systematic review was therefore to assess the studies present in the literature that analyze these new types of convergent or concave implant abutments or transmucosal profiles in comparison to the classic divergent or parallel profiles.

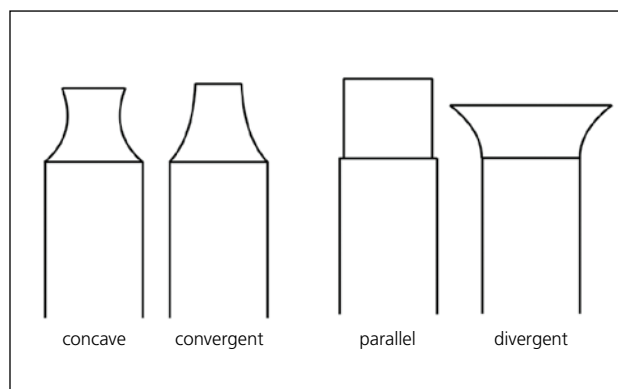


Fig 1 Schematic of the different types of transmucosal design.

MATERIALS AND METHODS

This review was registered at the National Institute for Health Research International Prospective Register of Systematic Reviews (PROSPERO; CRD42018113091).

The focus question was: In partially edentulous patients who receive dental implants as treatment, do concave/convergent profiles give different peri-implant soft tissue outcomes compared to divergent/parallel profiles?

The PICO (population, intervention, comparison, outcome) definitions were:

- Population: Partially edentulous patients
- Intervention: Concave/convergent implant transmucosal profiles
- Comparison: Divergent/parallel implant transmucosal profiles
- Outcome: Peri-implant hard tissue outcomes

Search Strategy

The data for this systematic review and meta-analysis were processed following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles.⁸

Relevant articles were searched through the MEDLINE/ PubMed and Cochrane Oral Health Group databases, with no date or language restrictions, using relevant keywords and respective Boolean operators:

- (((("dental implants"[MeSH Terms] OR ("dental"[All Fields] AND "implants"[All Fields]) OR "dental implants"[All Fields]) AND (((("dental implants"[MeSH Terms] OR ("dental"[All Fields] AND "implants"[All Fields]) OR "dental implants"[All Fields]) OR ("dental"[All Fields] AND "implant"[All Fields]) OR "dental implant"[All Fields]) AND ("administration, mucosal"[MeSH Terms] OR ("administration"[All Fields] AND "mucosal"[All Fields]) OR "mucosal administration"[All Fields]) OR

"transmucosal"[All Fields] AND design[All Fields] OR geometry[All Fields] OR abutment[All Fields]) OR (concave[All Fields] OR converging[All Fields]) OR (convex[All Fields] OR diverging[All Fields]) OR parallel[All Fields] AND jsubsetd[text]

The search was performed on August 7, 2018.

Inclusion Criteria

Clinical trials were considered for inclusion if all of these criteria were met:

- Human studies (randomized or nonrandomized)
- Follow-up time of at least 3 months
- At least 10 implants evaluated
- Information about the type of implant used (bone level or tissue level)
- Shape of the abutment or implant collar design clearly described, and data from convex and concave reported separately

Exclusion Criteria

Studies with the following characteristics were excluded:

- Retrospective
- Case series
- Same cohorts of patients
- Results not clearly expressed
- Inclusion criteria not met

Selection of Studies

Two authors (N.A.V. and M.W.) independently screened the titles derived from the initial search and, subsequently, the abstracts of the selected titles. The possible disagreements were resolved via discussion. Full texts were obtained from the selected abstracts and were independently screened by the same two reviewers according to the inclusion and exclusion criteria. The full texts resulting from the latter screening were double checked, and the conflicts were resolved by discussion among the reviewers before proceeding to data extraction.

Data Extraction

Three reviewers (N.A.V., M.W., and A.B.) independently performed the data extraction using an extraction table. To guarantee adequate calibration in the extraction process, the first article was analyzed together by the three reviewers in order to standardize all the following analyses.

The three extraction tables obtained independently by the three authors were compared to each other. In cases of data discrepancy, the articles were reanalyzed, and any conflict was resolved among the authors and confirmed by the statistician (P.T.).

In cases of insufficient data and/or of suspected reuse of the same patient cohort, the authors of the articles were contacted directly.

The following information was extracted: author(s); year of publication; study design; planned number and actual number of patients; dropouts; number and type of implants; type of connection; augmentation of soft tissues or bone; type of prosthetic rehabilitation; administration of antibiotics; follow-up time (range, mean); implant survival and success rates; number of implants lost and their positions in the oral cavity; number of infections; complications related to soft and esthetic tissues; final pink esthetic score (PES); and final marginal bone loss (MBL).

The primary outcome (MBL) and secondary outcomes (esthetic results, biologic complications, and implant/prosthesis failure) were classified as follows:

- MBL: peri-implant bone loss measured at the final radiologic check-up
- PES: measured after prosthetic loading
- Implant failure: classified as a failure if the published results indicated that the implants were not in function at the time of evaluation
- Biologic complications: abscess, pus, transient postoperative paresthesia, pain, swelling, and other adverse events
- Prosthetic failure: fixed prosthetic device detachment, loosening of abutment screw or healing cap, and fracture (screw, framework, or esthetic material)

Variables such as smoking and alcohol intake were considered as confounding factors for endosseous dental implant treatment, but were deemed too complex in these final outcomes and thus were not extracted. Subanalyses based on the presence of a PS or PM connection, when applicable, were also carried out.

Quality Assessment

Two authors (N.A.V. and P.T.) independently assessed the studies in terms of inclusion, relevance, eligibility, and risk of bias, in a standard and not-blinded way, following the Cochrane Collaboration tool.⁹ Any disagreement was resolved by consensus of the reviewers (N.A.V. and A.B.) and statistician (P.T.).

When split-mouth and parallel-arm RCTs were combined in the meta-analysis, the techniques described by Lesaffre et al were followed.¹⁰ Moreover, standard error (SE) of the intervention effect estimate in split-mouth RCTs was taken into account when an appropriate statistical approach accounting for the paired nature of the data was used.¹¹

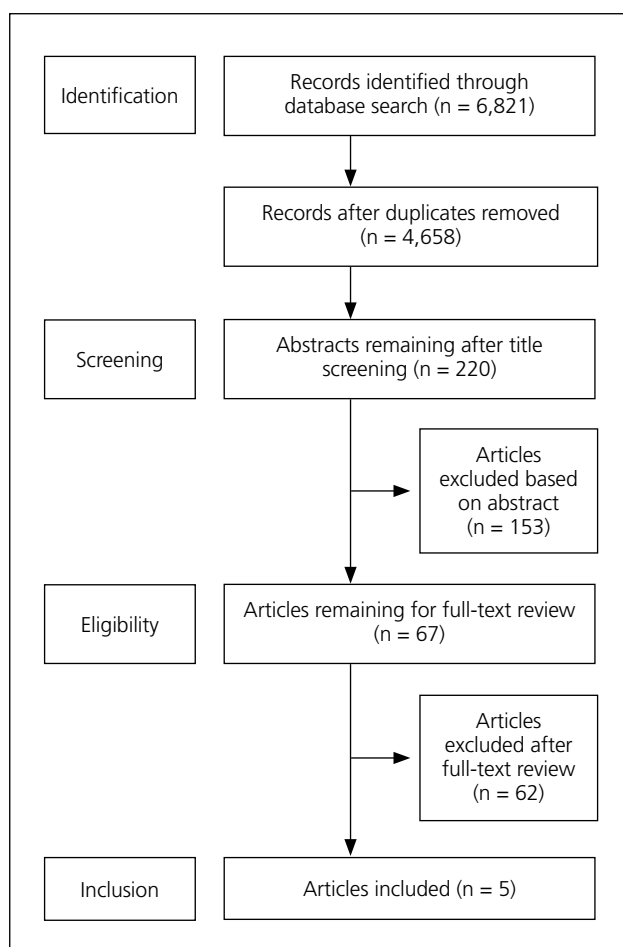


Fig 2 PRISMA flowchart of the study selection process.

Statistical Analysis

Implant and prosthesis failure, including biologic complications, were the dichotomous outcomes evaluated, whereas the PES and MBL were continuous outcomes. The statistical unit used for all analyses (implant failure, MBL, prosthesis failure, and biologic complications) was the patient. To assess the heterogeneity of the study-specific event outcomes, Cochran Q and I^2 statistics were performed, and the P value was also calculated.

All statistical analyses and graphic presentations were conducted using Comprehensive Meta-Analysis (CMA) software (version 2, Biostat). Confidence intervals (95% CIs) were calculated within the CMA software using the sample size (n) and SE, with a level of statistical significance set at $\alpha = .05$.

RESULTS

Search

The selection process of publications, reported in the PRISMA flow diagram (Fig 2), yielded 6,821 articles in the MEDLINE/PubMed and Cochrane Oral Health Group databases and additional sources. After title assessment, 220 articles were obtained. Further screening was carried out using abstracts, which led to the exclusion of 153 more articles. The full texts of the remaining 67 eligible studies were screened, and only 6 fulfilled the inclusion criteria. However, after contacting the authors who had published 2 of the 6 studies, it was confirmed that these 2 studies used the same cohort of patients. Consequently, only 1 of the 2 was used in this review, for a total of 5 articles.^{12–16}

Once a consensus was achieved, the characteristics, quality, and heterogeneity of the included studies were

Table 1 Risk of Bias Assessment of Included Studies

Study (y)	Risk of bias				
	Random sequence generation	Allocation concealment	Blinding of patients and surgeons	Blinding of outcome assessment	Incomplete outcome data
Canullo et al ¹² (2017)	NA	N/A	High	High	High
Esposito et al ¹³ (2018)	Low	Low	Low	High	Low
Patil et al ¹⁴ (2014)	NA	Low	High	Low	Low
Sánchez-Siles et al ¹⁵ (2018)	Low	Low	High	High	High
Weinländer et al ¹⁶ (2010)	High	Low	Low	High	Low

NA = not reported or unable to be extracted.

assessed using the Cochrane Collaboration tool (Table 1). In addition, a comprehensive overview of the included trials is reported in Table 2. Only a small number of studies compared the effects of transmucosal profile on hard and soft tissues, and, as a result, only one meta-analysis (with subgroup analyses) could be carried out.

Trials enrolled in the present review were ranked into the following categories:

- Group A: Studies that compared outcomes of standard implants with concave/convergent transmucosal profiles vs outcomes of standard implants with parallel/divergent transmucosal profiles
- Group B: Studies with information regarding concave/convergent transmucosal profiles, but not fulfilling the criteria for category A

Meta-analyses were performed to compare the results obtained from the studies reviewed in Group A.

Population Epidemiology

In the four studies in Group A,^{13–16} a total of 145 patients with 230 dental implants were included. Regarding the dichotomous outcome variables, no implant failure was registered, with a survival rate of 100% at 1 year of follow-up; nor was any prosthetic failure registered, with a survival rate of 100% at the 1-year survey.

Meta-Analysis of Studies in Group A

The study report stated that the pooled results for MBL within 12 months of follow-up found a significant effect in favor of implants with concave/convergent abutments or transmucosal profiles with a mean difference (MD)

of 0.209 mm (95% CI: 0.070 to 0.347 mm, $P < .001$), as illustrated in Fig 3a.

Even if the data suggest a net benefit for MBL resulting from a concave/convergent profile, no conclusions could be drawn regarding survival outcomes due to the 0% failure rate registered within the short-term survey of the enrolled studies and the fact that the studies did not report any complications at all within the follow-up period.

Regarding esthetic outcomes, the pooled results for PES within 12 months of follow-up found a nonsignificant effect ($P = .306$) in favor of implants with parallel/divergent abutments or transmucosal profiles with an MD of -0.349 (95% CI: -0.893 to 0.196), as illustrated in Fig 3b.

PS vs PM Interface Between Abutment and Implant

Data belonging to four studies were grouped into two categories according to the interface between abutment and implant. When MBL outcomes of concave/convergent and parallel/divergent profiles were compared on the basis of a further subdivision into PS and PM, a statistically significant effect in favor of the concave/convergent profiles in PS implants was obtained, with an MD of 0.147 mm (95% CI: 0.082 to 0.212 mm, $P < .001$) (Fig 3c). In the group with a PM interface, this advantage was not significant (Fig 3d).

DISCUSSION

The results of this systematic review and meta-analysis illustrate how implants with a concave or convergent transmucosal profile show better results in terms of MBL compared to implants with a parallel or divergent transmucosal profile. On the other hand, when esthetic parameters relating to the soft tissues were evaluated,

Risk of bias (other sources)

Selective reporting	Group imbalance	Sample size	Conflicts of interest	Radiographic outcomes	Enrolled for meta-analysis
High	NA	High	NA	Low	No
Low	Low	Low	High	Low	Yes
Low	Low	Low	Low	High	Yes
High	Low	Low	Low	High	Yes
Low	Low	High	Low	Low	Yes

Table 2 Comparison of Outcomes Considering Comparative Studies with an Observation Period from 3 to 12 Months Following Prosthetic Loading/Implant Placement

Study (y)	Total patients, n	Enrolled subjects, n	Groups in the study	Enrolled implants	Restoration retention	Bone/tissue level	Type of prosthesis	Immediate implants	Follow-up, mo	No. of dropouts, patients (implants)
Canullo et al ¹² (2017)	14	14	Concave/convergent	20	Cemented	Tissue level	SC	0	18	0 (0)
Level of significance										
Esposito et al ¹³ (2018)	94	49	Concave/convergent	49	Cemented	Bone level	SC, FPD	4	3	2 (NR)
			Parallel/divergent	49	Cemented	Bone level	SC, FPD	4	3	2 (NR)
Level of significance										
Patil et al ¹⁴ (2014)	29	26	Concave/convergent	26	Cemented	Bone level	SC	0	12	3 (3)
			Parallel/divergent	26	Cemented	Bone level	SC	0	12	3 (3)
Level of significance										
Sánchez-Siles et al ¹⁵ (2016)	60	60	Concave/convergent	30	NR	Bone level	SC	0	3	0 (0)
			Parallel/divergent	30	NR	Bone level	SC	0	3	0 (0)
Level of significance										
Weinländer et al ¹⁶ (2011)	10	10	Concave/convergent	10	Cemented	Bone level	SC	0	6, 12	0 (0)
			Parallel/divergent	10	Cemented	Bone level	SC	0	6, 12	0 (0)
Level of significance										

Level of significance refers to comparisons between concave and convex.

SC = single crown; FDP = fixed dental prosthesis; PM = platform matching; PS = platform switching; NA = not available; NR = not reported.

the PES values did not show any significant differences between the two categories of transmucosal profile.

Several dog model studies have investigated the influence of different types of transmucosal implant profiles (more specifically, concave and parallel/convex) at the histologic level on soft tissues and on bone. Gamborena et al¹⁷ showed no significantly different results for MBL or for peri-implant mucosal profiles when comparing concave abutments to parallel abutments in implants inserted in foxhound/labrador mongrel dogs using flap or flapless surgery. However, the abutments that were defined as “concave” in the Gamborena study present

in reality a parallel profile and a sudden enlargement at the coronal level, which, together with the PS, determine the formation of a large receding area. Delgado-Ruiz et al¹⁸ compared concave abutments to divergent abutments on implants inserted in foxhounds. At 3 months of healing, the peri-implant connective tissue was thicker around divergent abutments, and there was an increased presence of more perpendicular and oblique collagen fibers compared to concave abutments. However, looking at the photographs of the histologic sections, it seems that what the authors call “concave” actually appears



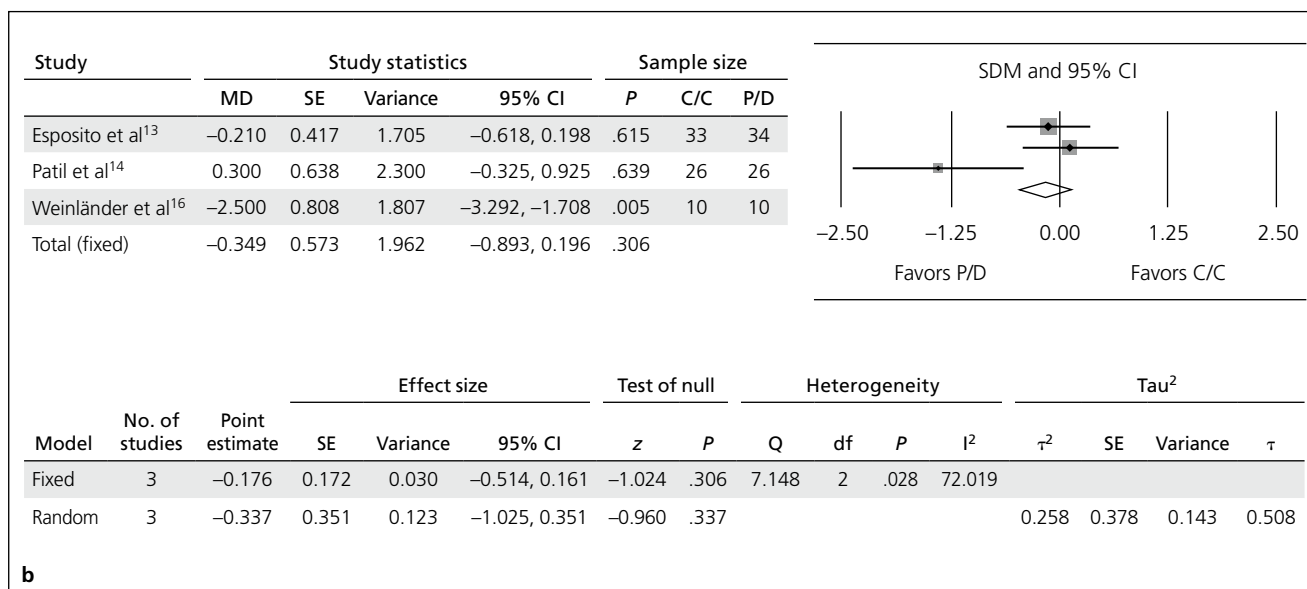
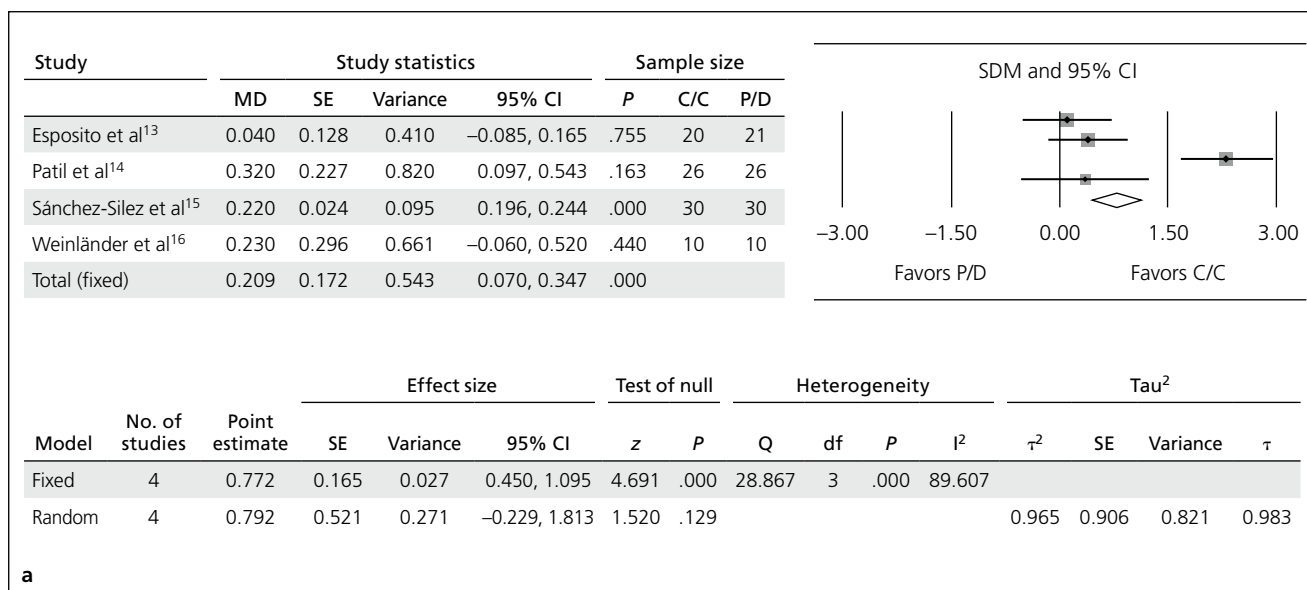
Bone/tissue grafting	Immediate loading	Type of connection	Implant failure (early/late)	Prosthetic failures	Complications	Sample size for soft tissue analysis, n	Soft tissue change (mean ± SD)	PES (mean ± SD)	Size for hard tissue analysis	Mean marginal bone change within 1 y, mm (mean ± SD)
20	20	NA	0 (0)	0	0	20	Mesial: 0.38 ± 0.22 Mid: 1.01 ± 0.63 Distal: 0.47 ± 0.31	NR	20	-0.09 ± 0.08 (range: -0.5 to 0.0 mm)
4	2	PS	0 (0)	0	0	33	NR	11.73 ± 1.70	20	-0.34 (0.43) (range: 0.14 to 0.54)
4	3	PS	0 (0)	0	0	34	NR	11.94 ± 1.71	21	-0.38 (0.39) (range: 0.20 to 0.55)
							-	<i>P</i> = .443		<i>P</i> = .817
0	26	PM	NR	NR	NR	26	NR	10 ± 2.3	26	-0.55 ± 0.81
0	26	PM	NR	NR	NR	26	NR	9.7 ± 2.3	26	-0.87 ± 0.83
							-	<i>P</i> = .41		<i>P</i> = .25
0	30	PS	0 (NR)	NR	0	30	NR	NR	30	-0.15 ± 0.06
0	30	PS	0 (NR)	NR	0	30	NR	NR	30	-0.37 ± 0.12
							-	-		<i>P</i> < .001
0	10	PM	0 (0)	0	NR	10	NR	8 ± 1.89 (range: 4 to 10)	10	-0.11 ± 0.77
0	10	PM	0 (0)	0	NR	10	NR	10.5 ± 1.72 (range: 7 to 13)	10	-0.34 ± 0.53
							-	<i>P</i> = .014		<i>P</i> > .3

more parallel. Therefore, a real concave profile cannot be considered in these cases.

Another well-designed study by Bolle et al¹⁹ showed how one-piece implants with a concave transmucosal profile—in this case, a groove present after the implant shoulder—favors the formation of circular collagen fibers, also called an O-ring, in the innermost part of the groove, with a thickness of 500 μm, which is much greater compared to the 50 to 100 μm highlighted in a similar study by Buser et al.²⁰ Not only was this area of connective tissue free of inflammatory infiltrate, but the initial convergence

of the one-piece transmucosal profile also prevented MBL even while favoring marginal bone apposition and gain.

These histologic studies in animal models show how the microscopic arrangement of the soft tissues, namely the supracrestal tissue attachment, influences marginal bone remodeling. For this reason, MBL was used as a primary outcome rather than a parameter related to soft tissues, because, in most of the clinical trials, soft tissue-related parameters were mainly evaluated at the macroscopic/aesthetic level. In summary, it can be assumed that the MBL values, although related to bone, reflect the influences of a well-formed peri-implant supracrestal

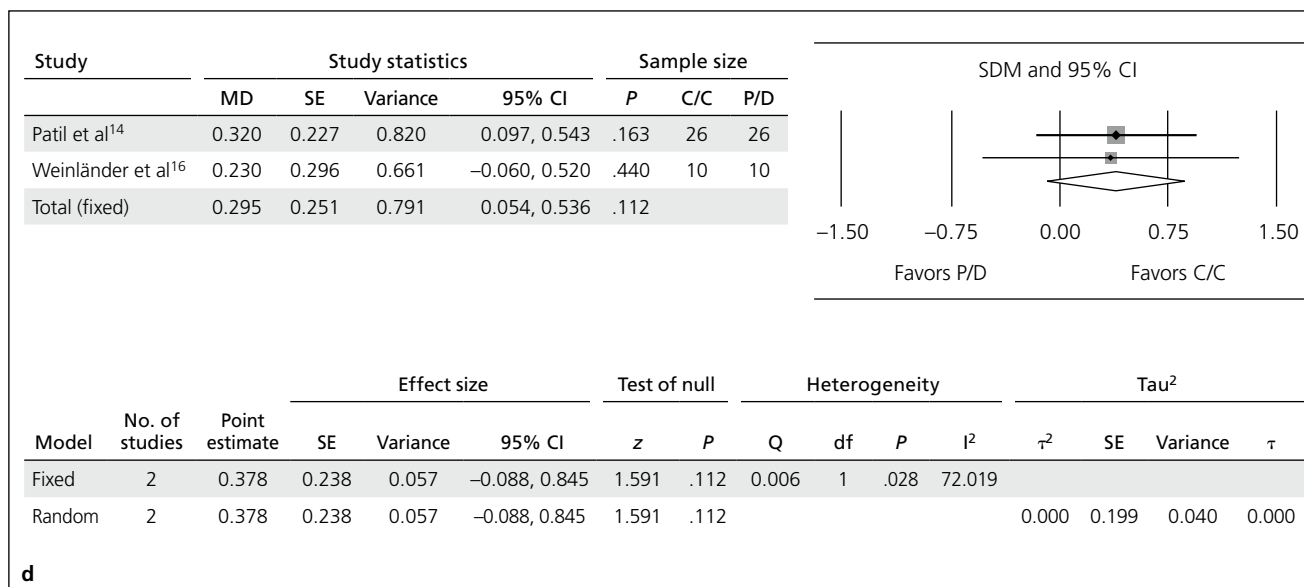
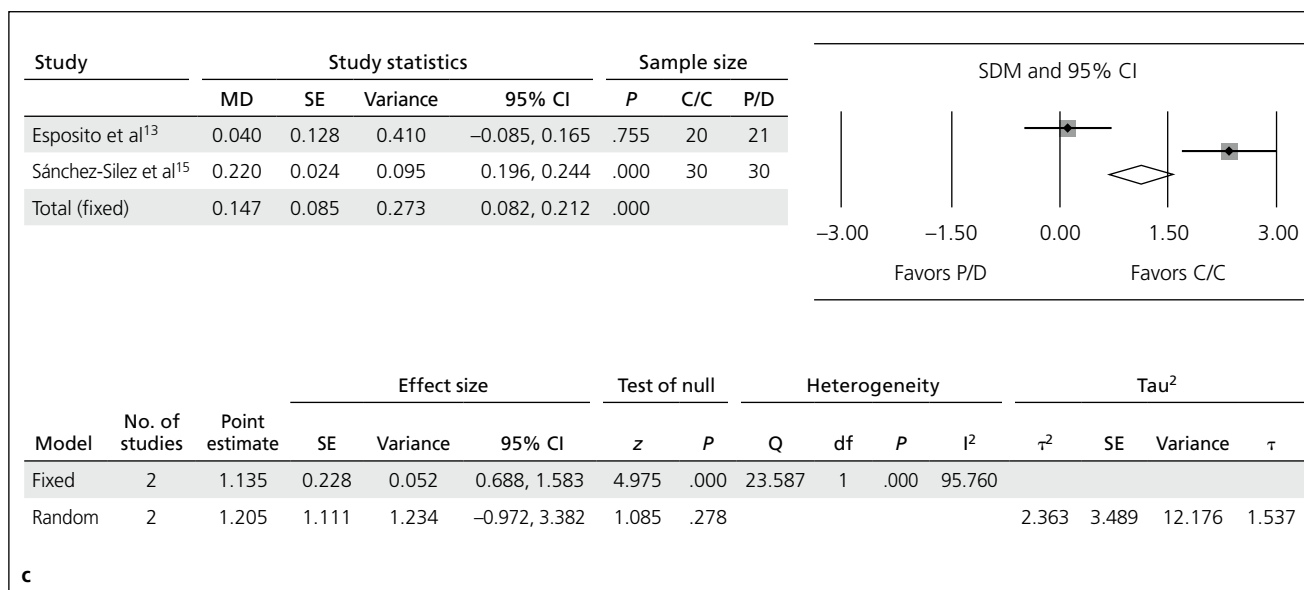


Figs 3a and 3b Forest plots for comparison of implants with concave/convergent and parallel/divergent abutments. (a) Marginal bone loss. (b) Pink esthetic score. MD = mean difference; SMD = standardized mean difference; C/C = concave/convergent; P/D = parallel/divergent.

soft tissue attachment on the bone itself, and the formation of this attachment might be influenced by the transmucosal profile.

The concept of a concave/convergent profile has also been tested in humans. One of the earliest studies from Rompen et al (2007)²¹ speaks of “above-average” esthetic results; however, the measured parameters were based on subjective scales and were not comparable with other studies, since neither MBL for hard tissues

nor PES for soft tissues were used. The aforementioned study refers in the text to convergent abutments; however, as in many other studies analyzed in this systematic review, they are actually macrogrooved abutments, and therefore rather concave. Weinländer et al¹⁶ used the same abutment with a macrogroove and seemed to obtain better MBL values in the study group compared to the control group at 1 year even if these values were not statistically significant, while the PES values were



Figs 3c and 3d Forest plots for comparison of implants with concave/convergent and parallel/divergent abutments. Marginal bone loss in implants with (c) platform-switching and (d) platform-matching connections. MD = mean difference; SMD = standardized mean difference; C/C = concave/convergent; P/D = parallel/divergent.

significantly in favor of the control group. The same type of abutment was used by Patil et al in several studies,^{14,22–24} two of which were included in this systematic review.^{14,22} However, after contacting the authors, they confirmed that the same patient cohort had been used in both. Rather than use both studies, it was therefore decided to use only the one from 2014 because it was the first published and because it also reported the MBL values. In Patil et al,¹⁴ the abutments of the test group,

presenting a groove width of only 1.25 mm with a convergence only 0.5 mm high, showed favorable results compared to the control group in terms of both PES and MBL, without achieving statistical significance. The study by Sánchez-Siles et al¹⁵ used an abutment with a groove similar to that of previous studies, but, in this case, it was a healing abutment, so only the 3-month osseointegration period was evaluated. Therefore, only

MBL values—which are statistically in favor of the test abutment—were considered.

In the study by Esposito et al,¹³ convergent abutments with a slight initial divergence were used, and the results of both PES and MBL were comparable, with a very slight tendency in favor of the test group for the MBL values and of the control group for the PES values. Neither of these values achieved statistical significance.

The meta-analyses of the clinical trials described above reveals a favorable effect given by the concave/convergent abutments with regard to MBL. This effect reached statistical significance ($P < .0001$), as shown in the forest plot (Fig 3a). Regarding esthetic outcome, the three studies that reported the PES values showed extreme variability, with two studies in favor of parallel/divergent profiles and a third in favor of concave/convergent profiles. The forest plot (Fig 3b) showed an effect in favor of the control group, although this difference was not statistically significant.

Marginal Bone Loss

In terms of MBL, which was significantly higher in the test groups, it can be hypothesized with a certain confidence that MBL was favorably influenced by a soft tissue thickness made greater by the particular anatomy of the transmucosal profiles of the test groups. In fact, many studies and systematic reviews have shown that an adequate soft tissue thickness, either preexisting or obtained by augmentation, represents a protective factor against MBL.^{25–28} In these terms, the MBL outcome (if it definitely represents a bone-related factor) is secondarily also a parameter indicative of the influence that the transmucosal profiles generally have on the soft tissues.

Pink Esthetic Score

The PES values did not differ significantly. This result, which can be interpreted at the level of the soft tissues but only in an esthetic sense, does not take into account the thickness of the peri-implant mucosa nor the height of the keratinized tissues, only considering evaluations that are strictly two-dimensional. Moreover, some of the parameters that make up the PES score can be influenced by the skills of the clinician and technician. For example, through careful and intelligent management of the temporary and final prosthetic restorations, the papillae can be induced to completely fill the interim-plant or tooth-implant space, and the mucous zenith can be brought to the desired height.²⁹ Indeed, the PES is a score that gives a value to the esthetics of the soft tissues but no information about whether the quality was more influenced by the correct positioning of the implant or by a wise and careful prosthetic restoration. The esthetic effect of transmucosal profile on the soft tissues should therefore be judged on the necessity, or

reduced necessity, of needing to resort to prosthetic manipulations or surgeries, but this is a parameter that would be difficult to measure. Also, the limited follow-up period (within 12 months) of the studies included in this systematic review does not allow for a proper evaluation of the PES itself for a longer period.

PS vs PM

It is interesting to note that, when a PS connection is associated with a concave/convergent profile, there is a significant favorable effect in terms of MBL; however, the same statistical significance is not achieved for PM connections. This may be due to the fact that the circular collagen fibers tend to migrate toward the narrower-diameter part of the implant profile (as shown in Rodríguez et al⁷). In PS connections, the narrowing effect of the abutment diameter might then be synergistic with the effect of the concavity of the profile. Thus, the PS prevents the fibers from invading the bone area, and the concavity provides for a stable housing of the same fibers.

The study by Canullo et al,¹² which was included in the systematic review but not in the meta-analyses (as it was missing a control group), showed encouraging results related to MBL, with an 18-month MBL of only 0.09 ± 0.08 mm and mean height gains for the distal papilla, mesial papilla, and marginal gingiva of 0.38 ± 0.22 mm, 0.47 ± 0.31 mm, and 1.01 ± 0.53 mm, respectively. All values were statistically significant, even if not comparable to any other study since the PES was not used.

It is important to highlight the extreme variability in the results, although some slight tendencies can be identified. The nonemergence of a clear tendency in favor of one group or the other is perhaps due to the nonhomogeneity in the design of the transmucosal profiles. In most studies, the profile of the abutments is concave rather than convergent—namely, it has a macrogroove, which, according to the study by Bolle et al,¹⁹ involves the migration of the O-ring of circular collagen fibers (the so-called “peri-implant circular ligament” mentioned by Ruggeri et al³⁰) toward the inside of this groove; ie, in the narrowest part. Just as described by Bolle et al,¹⁹ this circular ligament of collagen fibers, which is free of inflammatory infiltrate at the histologic level, represents a protection for the peri-implant bone. Indeed, these macrogrooved abutments create a concavity that “entraps” the collagen fibers, and the size of this concavity (or groove) also influences the height of this circular ligament. Thus, a shorter groove can determine a shorter connective tissue component, just as seen in Bolle et al,¹⁹ where the implant, although one piece, presented a macrogroove very similar to that of most of the studies included in this review. All the above leads to the hypothesis that a real continuous convergence of the transmucosal profile during soft tissue healing



without a sharp divergence (as in grooves) could lead to the migration of the circular fibers into a more apical position, as demonstrated by Rodríguez et al.³¹ This would lead to a larger area of peri-implant connective tissue and a higher position of the circular fibers, which would thus prevent the apical migration of the peri-implant mucosa and offer a wider marginal protection zone. Furthermore, this convergent profile could allow the restorative margin to be positioned at the desired level and able to be changed according to the desired height so as to condition the soft tissues, similarly to what happens in the biologically oriented preparation technique (BOPT) described by Loi and Di Felice.³²

The only study among those analyzed in this systematic review that presents a strictly convergent transmucosal profile is that of Canullo et al,¹² which could not be included in the meta-analysis. The implants used in this study were tissue level, meaning there was no connection and, consequently, no presence of a microgap subject to potentially harmful bacterial infiltrations.³³ In a dog model in the study by Bolle et al,¹⁹ the absence of the microgap and the convergence of the profile led to the apposition of bone, which in turn led to a gain of MBL. Therefore, the association of these two potentially beneficial factors (convergent transmucosal profile and absence of connection) deserves, in the present authors' opinion, more in-depth clinical studies.

An interesting reflection is how the design of the peri-implant transgingival profile can impact the risk of developing peri-implant disease. In a recent study by Katafuchi et al,³⁴ it was noted that the presence of an angle-of-emergence profile greater than 30 degrees associated with a convex restorative profile involved a significantly increased risk of peri-implantitis.

A limiting and possibly confounding factor of the analysis presented herein is the variability in the definitions of "concave" and "convergent"; in fact, some authors define what is actually concave as convergent. This inconsistency is certainly influenced by the novelty of the subject, which does not allow for a generally accepted definition of each different design. Another limitation is the scarcity of studies on the subject and the short follow-up periods. It is hoped that this problem will be overcome in the foreseeable future and that new meta-analyses can be performed with more solid studies. The studies are not only few in number but also very recent, with follow-up periods that are still relatively short. This influenced the choice of a 3-month follow-up as an inclusion criterion. Nonetheless, these preliminary results deserve to be shared.

CONCLUSIONS

Although the limited number and variability of the studies included in this systematic review cannot clearly

indicate a trend in favor of one group or another, it is believed that, based on the statistically significant tendency observed toward better results in terms of MBL for concave/convergent transmucosal profiles and in anticipation of new implants with strictly convergent and tissue-level profiles, these types of profiles could be beneficial for MBL. This topic deserves to be investigated in future studies.

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Literature Abstract

Immediate Dental Implants Placed into Infected Sites Present a Higher Risk of Failure than Immediate Dental Implants Placed into Non-Infected Sites: Systematic Review and Meta-Analysis

Alveolar infection is known as a risk factor for implant failure. Current meta-analyses on this subject could not prove statistically that immediate dental implants placed into infected sites have a higher risk of failure than immediate dental implants placed into noninfected sites. The purpose of this meta-analysis was to determine the effectiveness of immediate dental implants placed into infected vs noninfected sites. Seven databases were searched by two reviewers. Randomized or nonrandomized clinical trials that compared the placement of dental implants into infected vs noninfected sites were eligible for the study. Exclusion criteria were: papers in which the survival rate was not the primary outcome; papers without a control group; studies with less than 1 year of follow-up; studies in which patients did not receive antibiotic therapy; studies with medically compromised patients; and duplicate papers. Risk of bias assessment was performed with the Cochrane Collaboration tool. Of the 3,253 initial hits, 8 studies were included in both the qualitative and quantitative syntheses ($\kappa = 0.90$; very good agreement). The forest plot for implant failure showed that immediate implants placed into infected sites presented a statistically significant risk of failure almost 3 times higher than when placed into noninfected sites (risk ratio = 2.99; 95% CI: 1.04 to 8.56; $P = .04$; 935 implants; $I^2 = 0\%$). Peri-implant outcomes showed no statistical difference. Immediate dental implants placed into infected sites presented a statistically significantly higher risk of failure than immediate dental implants placed into noninfected sites. Peri-implant outcomes were not statistically affected in this intervention.

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