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The influence of abutment disconnections on peri-implant marginal bone: A systematic review

KEY WORDS

alveolar bone loss, dental implants, implant restoration, review

ABSTRACT

Purpose: To assess the failure rate of dental implants and prosthetic restoration, complications and marginal bone loss (MBL) of implants restored with an immediate definitive abutment at the time of the implant placement, and implants that were evaluated according to a standard prosthetic protocol (SPP), which includes multiple abutment changes.

Materials and methods: This systematic review followed the guidelines of the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). An electronic search with no date or language restriction was run in January 2018 in the PubMed/MEDLINE, Cochrane Central Register of Controlled Trials, Web of Science, and complemented with a manual search. Randomised clinical trials with at least a 12-month follow-up evaluating the use of a definitive abutment and a SPP were included. The Cochrane Collaboration Risk of Bias tool was used to evaluate the included studies. The outcome measures were: implant and prosthetic failure; aesthetics; complications; and peri-implant MBL. The results were pooled using a random-effect model with mean differences (MDs) for continuous outcomes and risk ratio for dichotomous outcomes with a 95% confidence interval (CI).

Results: The search identified a total of 714 studies. After the screening process five studies were included in the analysis. The five studies included had a limited sample size, a short follow-up period, and four studies were considered at high risk of bias. The meta-analysis revealed that five studies using an immediate definitive abutment over a 12- to 18-month follow-up resulted in lower MBL, with a MD of –0.32 mm (95% CI –0.45 to –0.19: $P < 0.0000$). At the end of a 3-year follow-up two studies showed a MD of –0.33 mm (95% CI –0.63 to –0.03: $P = 0.03$, which also favours the definitive abutment group. Regarding implant failure rate, complications, and probing depth, no significant difference was found between the groups.

Conclusions: Within the limitations of this meta-analysis, reducing the number of abutment changes contributes to statistically significant lower MBL. However, the clinical significance of this reduction in bone loss should be interpreted with caution. A high implant success rate was reported by all studies for both control and test groups.

Conflict of interest statement: *The authors declare that they have no conflicts of interest. No funding was received for this review.*

Introduction

The crestal bone resorption that two-piece implants undergo after the connection of the abutment and delivery of prosthesis is well documented in the literature[1-5]. The marginal bone level around implants can be affected by different biological and mechanical aspects, such as implant diameter[6], timing of implant placement and the implant-abutment junction position in relation to the bone crest[7].

Another factor that can influence marginal bone loss (MBL) around implants is the repeated exchange of abutments. The harmful potential of repeated changes of abutment has been investigated in preclinical studies[8-10]. These studies indicated that this procedure damages the mucosal barrier around implants, resulting in a more apically positioned zone of connective tissue and marginal bone resorption. On the other hand, two animal studies that limited the number of abutment shifts to only two[11], or used a platform switch system[12] reported conflicting results with no differences in regard to hard tissue alterations.

The standard prosthetic protocol (SPP) for the fabrication of a final implant-supported prosthesis comprises multiple changes of abutments. However, to avoid the potential harm caused by repeated abutment exchanges, the 'one abutment – one time' concept was developed. This protocol recommends the use of a definitive abutment at the time of implant placement that is not removed throughout the course of the prosthetic treatment. Recent randomised clinical trials (RCTs) assessing the effects of the two above-mentioned prosthetic protocols reported a statistically significant reduction in bone loss for implants restored with a definitive abutment[13-20]. Nevertheless, the clinical relevance of this reduced crestal bone resorption remains controversial.

Further systematic reviews are required to evaluate the existing scientific evidence and provide dental clinicians with evidence-based guidelines for clinical decision-making. Thus, the purpose of this systematic review was to assess the clinical outcomes of implants restored with: 1) a definitive abutment at the time of implant placement; or 2) a SPP.

Materials and methods

The review methodology was conducted according to the PRISMA statement[21] (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The PICO framework[22] was used to create a clinical question and guide the search strategy (Table 1). The review was registered in the international prospective register of systematic reviews (PROSPERO – CRD42016049800).

Formulating the review question

The PICO strategy was used to formulate the following question: "do dental implants restored with a definitive abutment or a SPP present differences in the clinical outcome?"

Inclusion/exclusion criteria

Eligible studies comprised RCTs with at least a 12-month follow-up after the intervention, which included the use of an immediate definitive abutment at the implant placement, and an implant placement using a SPP.

Outcome measures

- primary outcomes: implant and prosthetic failure, and complications;
- secondary outcomes: peri-implant marginal bone level changes measured by the use of periapical radiographs; probing depth, measured by differences observed in probing depths; and aesthetic evaluation.

Search methodology

An electronic search, with no language or date restriction, was conducted in MEDLINE/PubMed, Web of Science, the Cochrane Central Register of Controlled Trials, and the System for Information on Grey Literature in Europe (OpenGrey), in January 2018. In addition, a hand search was also performed in dental and implant-related journals, including the following: Clinical Implant Dentistry and Related Research, Clinical Oral Implants

Table 1 Systematic search strategy (PICO strategy)

Population #1	"dental implant" [MeSH Terms] OR "immediate dental implant loading" [MeSH Terms] OR "dental implant" [text word]
Intervention #2	"definitive abutment" [All Fields]
Comparison #3	"provisional abutment" [All Fields] OR "healing abutment" [All Fields]
Outcome #4	"Alveolar bone loss"[MeSH Terms] OR "marginal bone loss"[All Fields] AND (Randomised Controlled Trial[ptyp] AND "humans"[MeSH Terms])
Search combination	#1 AND #2 AND #3 AND #4
Language	No restriction
Electronic database	MEDLINE/PubMed, Web of Science, and Cochrane Central Register of Controlled Trials

Table 2 Search strategy

Databases	Strategy used to search the literature
PubMed	(((((dental implants [MeSH Terms]) OR immediate dental implant loading[MeSH Terms]) AND definitive abutment) AND provisional abutment) AND alveolar bone loss[MeSH Terms]) OR marginal bone loss
Web of Science	(dental implant) and (definitive abutment) OR (provisional abutment) AND (marginal bone loss)
Cochrane Central of Controlled Trials	(dental implant) and (definitive abutment) OR (provisional abutment) AND (marginal bone loss)
OpenGrey	(dental implant) and (definitive abutment) OR (provisional abutment) AND (marginal bone loss)

Research, International Journal of Oral & Maxillofacial Implants, International Journal of Oral and Maxillofacial Surgery, International Journal of Prosthodontics, Journal of Dental Research, Journal of Oral Rehabilitation, Journal of Prosthodontics, European Journal of Oral Implantology, and Journal of Prosthetic Dentistry (Table 2).

Screening process and data extraction

Two reviewers (J.G.B and E.P.B) independently screened the titles and abstracts, and read the papers carefully and assessed them according to the eligibility criteria for data extraction. Differences between the reviewers were resolved by a third author (D.L).

Data were extracted from the studies by two authors (J.G.B and E.P.B) independently. The following information was extracted from the included studies: study design, number of participants, type of occlusion at initial loading, mean age and sex of participants, follow-up period, type of connection system, quantity and characteristics of implants (length, diameter, manufacturer and surface), implant survival, primary stability, implants placed in fresh sockets, number of smokers, use of platform switch, and number of drop-outs. Data regarding each study is presented in Table 3.

Quality assessment

To assess the quality of the selected RCTs, the Cochrane Collaboration Risk of Bias tool for assessing risk of bias[23] in RCTs was used by two reviewers (J.G.B and E.P.B) independently. The following parameters were included: random sequence generation, allocation concealment method, blinding of outcome assessment, incomplete data outcome, selective outcome reporting, and other potential sources of bias. The risk of bias was categorised as follows: 1) low risk of bias if the study met all criteria; 2) unclear risk of bias if one or more criteria were at an unclear risk of bias; and 3) high risk of bias if one or more criteria were not met.

Data synthesis

Quantitative data analysis was conducted using the Review Manager statistical software (version 5.3, The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark, 2014). The estimate of relative effect for the dichotomous outcome (implant failure and complications) was expressed as a risk ratio with confidence intervals (CIs) of 95%. The continuous outcome measures (marginal bone level, probing depth and aesthetics) were expressed as mean difference (MD) and standard deviations with 95% CIs. The I^2 statistical

Table 3 Main characteristics of included studies

Reference	Follow-up period (months)	Patients, n (sex distribution), per group	Mean age, per group	Region	Implants placed/ failed, n	Drop-outs, n	Implants brand/ surface	Implant size (diameter x length, mm)	Platform switch	Insertion torque required for inclusion, N cm	Occlusal contact	Fresh extraction socket	
Canullo et al[13]	36	E: 15 (6F/9M) C: 10 (3F/7M)	E: 51 C: 55	Maxillary premolar	25/0	0	Global implants/ rough	5.5 x 13	Yes	32 to 45	Non occlusal	Yes	
Grandi et al[14]	12	E: 14 (9F/5M) C: 14 (8F/6M)	E: 53.2 C: 50.3	Maxillary or mandibular	56/0	0	JDEvolution/ rough	3.7, 4.3, 5 x 10, 11.5, 13	Yes	≥ 45	Non occlusal	No	
Grandi et al[17]	12	E: 12 (7F/5M) C: 13 (9F/4M)	E: 56 C: 57.08	Maxillary or mandibular	25/0	0	JDEvolution/ rough	3.7, 4.3 x 11.5, 13	Yes	≥ 45	Non occlusal	Yes	
Bressan et al[19]	36	E: 40 (23F/17M) C: 40 (24F/16M)	E: 57.6 C: 55.6	Partially edentulous maxilla and mandible	73/1	E: 6 C: 1	Ankylos, Dentsply/ rough	3.5, 4.5, 5.5 x 8, 9.5, 11, 14	Yes	≥ 35	Non occlusal	Yes	
Molina et al[20]	12	E: 18 (7F/11M) C: 21 (10F/11M)	E: 52.6 C: 51.6	Posterior maxillary or mandibular	60/1	E: 2 C: 2	Camlog, Conelog screw-line/ rough	3.8, 4.3 x 9, 11, 13	Yes	NR	Non occlusal	No	

C, control; E, experimental; NR, not reported; SD, standard deviation.

test was used to assess heterogeneity between studies, with I^2 values above 75% corresponding to high heterogeneity. When a high heterogeneity was found ($P < 0.10$) the random-effects model was used; when a low heterogeneity was found the fixed-effect model was used. Statistical significance was accepted at $P < 0.05$. Data from the parallel and split-mouth studies were combined using the option of generic inverse variance method available in the Review Manager software.

Unit of analysis issue

The statistical unit was the patient and not the implant.

Results

Study selection

The electronic database search yielded 480 results in MEDLINE/PubMed, 179 in Web of Science, and 55 in the Cochrane Central Register of Controlled trials. After duplicates were removed, 667 articles remained. After reading the title and abstracts, 658 studies were excluded with nine articles to be read in full. Among the nine articles, three[15,18,24] were excluded because they did not fit the eligibility criteria (Table 4). In addition, one study[16] was excluded since it failed to specify the number of drop-outs per group, which did not allow determination of the number of patients at 1 year follow-up (Table 4). The authors of that study[16] were contacted but did not reply. The selection process

	Type of implant-abutment connection	Type of immediate provisional restoration	Control group abutments disconnections, n	Marginal bone Loss, mm (mean ± SD)	Probing depth, mm	Smokers	Author conclusions
	Double internal connection	Cemented	NR	E: 0.34 ± 0.07 C: 0.55 ± 0.09	E: 2.75 ± 0.07 C: 2.80 ± 0.21	NR	Despite the statistically significant difference in peri-implant marginal bone loss of 0.2 mm observed 3 years after implant placement favouring the 'one time-one abutment' concept no clinically visible differences could be observed in postextraction immediately restored platform-switched implants. More randomised clinical trials are needed to properly investigate this matter.
	Conical connection with internal hexagon	Cemented	4 times	E: 0.094 ± 0.025 C: 0.435 ± 0.025	NR	E:4 C: 5	It can be suggested that the non-removal of abutments placed at the time of surgery results in a statistically significant reduction of the crestal bone resorption around the immediately restored implants in cases of partial edentulism, however, a difference of 0.3 mm may not have a clinical impact.
	Conical connection with internal hexagon	E: cemented C: screwed	At least 3 times	E: 0.108 ± 0.0631 C: 0.583 ± 0.111	NR	E: 5 C: 4	The non-removal of abutments placed at the time of surgery resulted in 0.5 mm less peri-implant marginal bone resorption around immediately restored post-extractive single implants.
	Internal connection	NR	3 times	E: 0.11 ± 0.2 C: 0.61 ± 1.0	NR	E: 8 C: 12	The 3-year post-loading data showed that repeated abutment disconnections significantly increased bone loss (0.43 mm), but this difference cannot be considered clinically relevant, therefore, clinicians can use the procedure they find more convenient for their specific patient.
	Morse taper	NR	2 times	E: 0.59 ± 0.322 C: 1.210 ± 0.816	E: 3.18 ± 0.54 E: 3.06 ± 0.75	E: 8 C: 9	The connection and disconnection of healing abutments is associated with significantly increased bone loss during the healing period between implant placement and 6 months post-loading, when compared to one-time abutment placement.

is shown in detail in Figure 1 and the individual characteristics of the five RCTs included in the present qualitative analysis are shown in Table 3.

Study characteristics

Characteristics of trial settings and investigators

Among the five trials included in the present review, four[13,14,17,19] were conducted in private practices and one[20] in a postgraduate university clinic. Four trials[13,14,17,19] were performed in Italy, and one[20] in Spain. All trials had a parallel-group design[13,14,17,19,20]. Two studies were partially funded by the implant manufacturer[19,20].

Table 4 Excluded studies

Reason for exclusion	Reference
Less than 12-month follow-up	Koutouzis et al[15]
Case series	Degidi et al[24]
Abutment changes were made in both control and test groups	Nader et al[18]
Missing data	Degidi et al[16]

Characteristics of participants

A total of 211 volunteers participated in the trials. A total of 289 implants were placed and the follow-up period ranged from 12 to 36 months.

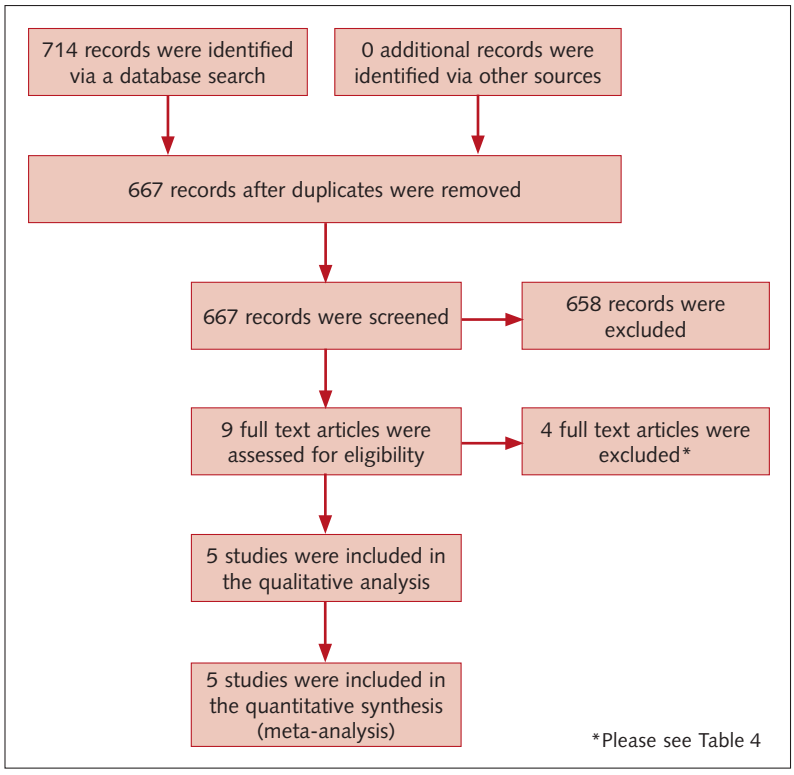


Fig 1 Flow chart of screening and selection process (PRISMA format).

Characteristics at baseline

The main inclusion criteria in the trials were as follows:

- at least 18 years of age[13,14,17,19,20];
- presence of at least 4 mm of bone beyond the root apex[13];
- intact alveolar bone walls[13];
- maximum score for plaque index = 2[14,17];
- adequate bone quality and availability[20];
- presence of opposing dentition[13,14,17,19,20].

The main exclusion criteria in the trials were as follows:

- systemic disease that could compromise osseointegration[14,19,20];
- treatment or medication that could compromise bone metabolism[14,17,20];
- smoking more than 10 cigarettes per day[13,14,20] or 20 cigarettes per day[17];
- pregnancy or lactation[13,14,19];
- alcoholism or drug abuse[17,19,20];
- bruxism[14,20].

Characteristics of the intervention

All studies[13,14,17,19,20] investigated the use of a definitive abutment and a SPP as test and control group, respectively. All studies[13,14,17,19,20] used platform switch and rough surface implants. In addition: three studies placed implants in fresh extraction sockets[13,17,19]; three studies placed implants in edentulous healed sites[14,19,20]; four studies reported the use of a flapless approach[13,14,17,19]; and one study did not specify the type of flap design[20].

Regarding the primary implant stability, four studies specified the required insertion torque for the implant[13,14,17,19]. The lowest requirement was ≥ 25 Ncm. One study used direct hand testing to assess implant stability[20].

Four studies used a provisional restoration[13,14,17,19]. One study used a healing abutment as control group and a definitive abutment with a titanium protection cap as test group[20]. All studies reported a temporary non-occlusal loading of the implants[13,14,17,19,20]. Two studies used a cement-retained provisional restoration[13,14], and one study used a combination of the cement-retained option as test group and screw-retained as control group[17].

Sample size

Only three studies reported a priori sample size calculation[13,19,20].

Risk of bias

The final risk of bias assessment of the studies included in the present review is summarised in Table 5, and the individual support for judgement for every topic and risk of bias summary is presented in Figure 2.

Other potential source of bias

A protocol violation regarding the allocation concealment procedure was detected in the study by Bressan at al[19]. The results of the risk of bias assessment are described in Figure 2. None of the studies met all the criteria[24]; four studies were considered

Table 5 Risk of bias assessment

Bias	Bressan et al[19]	Canullo et al[13]	Grandi et al[14]	Grandi et al[17]	Molina et al[20]
Random sequence generation (selection bias)	Low risk	Low risk	Low risk	Low risk	Low risk
Support for judgement	Six computer-generated restricted random lists were created.	The randomisation list was provided by a statistician unaware of the study protocol using a random number generator utility.	Participants were randomly assigned following simple randomisation procedures (computerised random numbers) to one of two treatment groups.	The randomisation list was provided using computer-generated random numbers.	The randomisation sequence was created using a computer-generated list using Excel 2010 (Microsoft, Redmond, WA, USA) with a 1:1 allocation using random block sizes 4.
Allocation concealment (selection bias)	Low risk	High risk	High risk	High risk	Low risk
Support for judgement	Only one investigator (Esposito M), who was not involved in the selection and treatment of the patients, knew the random sequence. The random codes were enclosed in sequentially numbered, identical, opaque, sealed envelopes. Only after the implants were placed, the envelope corresponding to the patient recruitment number was opened and the clinician was informed whether to place a definitive or a healing abutment.	The surgeon was informed of the allocation of each patient shortly before tooth extraction, by unsealing a closed envelope; therefore, the allocation was not concealed.	The surgeons who inserted the implants were informed by the study coordinator about the allocation before the implant placement by email or phone.	The surgeon was informed of the allocation of each patient shortly before tooth extraction by unsealing a closed opaque envelope; therefore, the allocation was not concealed.	The allocation concealment was kept by means of opaque-sealed envelopes that were opened by one of the researchers (Sanz-Sánchez I) during surgery immediately after implant insertion.
Blinding of outcome assessment (detection bias)	Low risk	Low risk	High risk	Low risk	Low risk
Support for judgement	At each centre there was a local blind outcome assessor who recorded implant stability, recessions, height of the keratinised mucosa and patient satisfaction.	All radiographic measurements were made and collected by the same trained blinded examiner. All measurements were made by an independent calibrated examiner.	Measurements were carried out by an expert operator in the three private dental offices involved in the trial, which was not blinded to group allocation.	All measurements were taken by an independent blinded assessor.	One blinded and calibrated examiner recorded all the outcomes.
Incomplete outcome data (attrition bias)	Low risk	Low risk	Low risk	Low risk	Unclear risk
Support for judgement	Seven patients dropped out 3 years after the start of the follow-up. From the six patients in the definitive abutment group: one patient moved to a different town 4 months after the start of the follow-up; one patient died of a heart attack just before the first year of the follow-up; one patient did not return for follow-up due to a severe stroke after 1 year; and one patient refused to return for follow-up due to malaria infection. One patient in the repeated disconnection group attended the follow-up for the last time 2 years after the start of the period due to distance.	No drop outs.	No drop-outs.	No drop-outs.	The number of drop-outs was given but the reasons were not provided.

Table 5 (cont.) Risk of bias assessment

Bias	Bressan et al[19]	Canullo et al[13]	Grandi et al[14]	Grandi et al[17]	Molina et al[20]
Selective reporting (reporting bias)	Low risk	Low risk	Low risk	Low risk	Low risk
Support for judgement	All planned outcomes apparently reported	All planned outcomes apparently reported	All planned outcomes apparently reported	All planned outcomes apparently reported	All planned outcomes apparently reported
Other bias	High risk	Low risk	Low risk	Low risk	Low risk
Support for judgement	A protocol violation, noted by the study monitor at Luongo G' department, comprised the opening of random codes before implant insertion in two patients, thus invalidating the allocation concealment procedure. It is not possible to quantify for how many other patients this protocol deviation occurred.	None apparent	None apparent	None apparent	None apparent

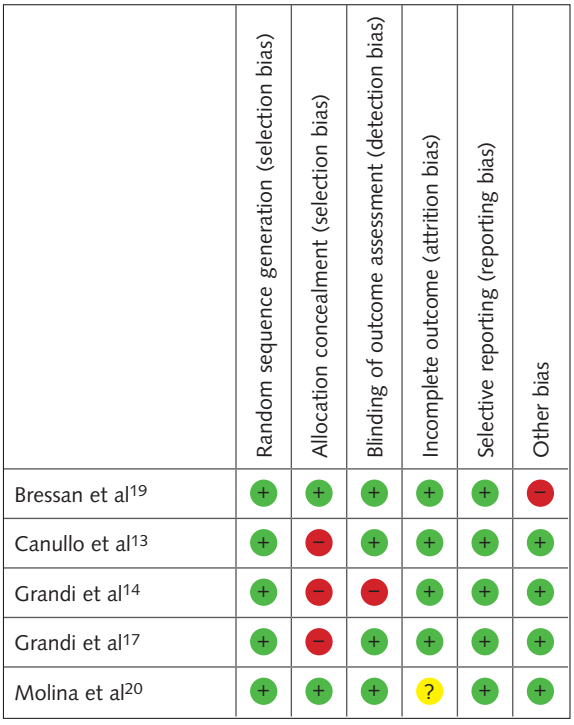


Fig 2 Quality assessment of included studies.

to have a high risk of bias[13,14,17,19]; and one study was at an unclear risk of bias[20].

Implant failure

All studies presented a high survival rate, with only two implant failures reported[19,20], with no significant statistical difference between the groups at 12 to 18 months ($P = 0.43$; RR: 3.53 , 95% CI: 0.15, 81.11) and at 36 months ($P = 0.55$; RR: 0.38, 95% CI: 0.02, 9.05) (Fig 3). In one trial, an implant loss from the definitive abutment group occurred due to a premature failure 1 week postsurgery[20], and in another trial an implant belonging to the SPP group failed after almost 3 years in function[19]. The authors reported that the same implant was previously affected by prosthesis debonding and peri-implantitis before fracturing[19].

Prosthetic failure

One study reported that seven crowns in the SPP group and one crown in the definitive abutment group had to be remade. However, the authors mentioned that the use of nonindexed abutments in the indexed implants was the cause for the poor fitting of six of the crowns that had to be remade in the SPP group[19]. The same study also reported that one crown in the definitive abutment group had to be remade because it fractured 6 months after delivery[19]. The meta-analysis showed no statistical difference between the groups at 12 to 18 months ($P = 0.10$; RR: 0.18, 95% CI: 0.02, 1.39) and at 36 months ($P = 0.55$; RR: 0.38, 95% CI: 0.02, 9.05) (Fig 4).

Complications

Two patients from the definitive abutment group and one patient in the SPP group with single crown restorations in the study by Molina et al[20]

Study or sub-group (follow-up duration, months)	DA Events	DA Total	SPP Events	SPP Total	Weight	Risk ratio M-H, Fixed, 95% CI
Bressan et al[19] (12)	0	38	0	40		Not estimable
Canullo et al[13] (18)	0	15	0	10		Not estimable
Grandi et al[14] (12)	0	14	0	14		Not estimable
Grandi et al[17] (12)	0	12	0	13		Not estimable
Molina et al[20] (12)	1	16	0	19	100%	3.53 [0.15, 81.11]
Total (95% CI)		**95**		**96**	**100%**	**3.53 [0.15, 81.11]**
Total events	1		0			

Heterogeneity: Not applicable

Test for overall effect: Z = 0.79 (*P* = 0.43)

a

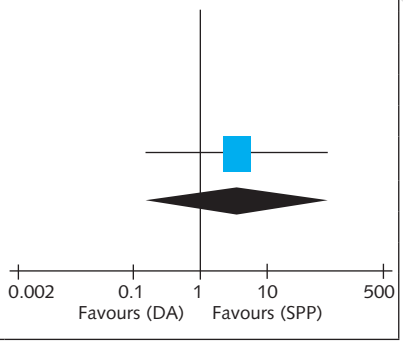


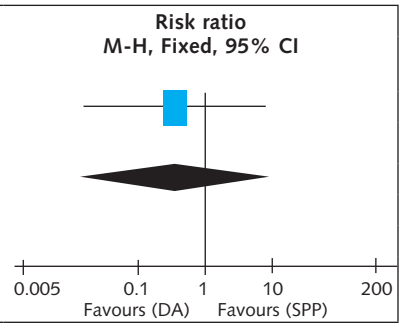
Fig 3a-b Forest plot for event 'implant failure' at different follow-up periods: **(a)** 12 to 18 months; **(b)** at 36 months. DA, definitive abutment; SPP, standard prosthetic protocol.

Study or subgroup	DA Events	DA Total	SPP Events	SPP Total	Weight	Risk ratio M-H, Fixed, 95% CI
Bressan et al[19]	0	34	1	39	100%	0.38 [0.02, 9.05]
Canullo et al[13]	0	15	0	10		Not estimable
Total (95% CI)		**49**		**49**	**100%**	**0.38 [0.02, 9.05]**
Total events	0		1			

Heterogeneity: Not applicable

Test for overall effect: Z = 0.60 (*P* = 0.55)

b



Study or sub-group (follow-up duration, months)	DA Events	DA Total	SPP Events	SPP Total	Weight	Risk ratio M-H, Fixed, 95% CI
Bressan et al[19] (12)	1	38	6	40	100%	0.18 [0.02, 1.39]
Canullo et al[13] (18)	0	15	0	10		Not estimable
Grandi et al[14] (12)	0	14	0	14		Not estimable
Grandi et al[17] (12)	0	12	0	13		Not estimable
Molina et al[20] (12)	0	16	0	19		Not estimable
Total (95% CI)		**95**		**96**	**100%**	**0.18 [0.02, 1.39]**
Total events	1		6			

Heterogeneity: Not applicable

Test for overall effect: Z = 1.65 (*P* = 0.10)

a

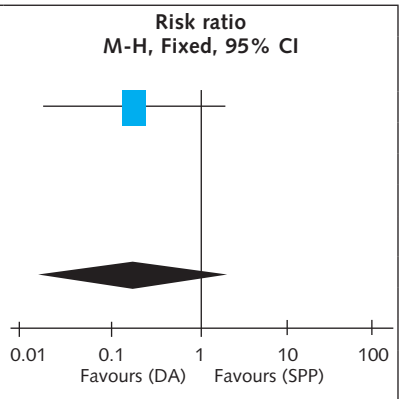


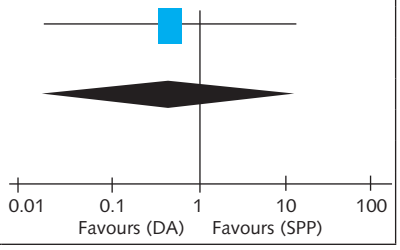
Fig 4a-b Forest plot for 'prosthetic failure' at different follow-up periods: **(a)** 12 to 18 months; **(b)** 36 months. DA, definitive abutment; SPP, standard prosthetic protocol.

Study or subgroup	DA Events	DA Total	SPP Events	SPP Total	Weight	Risk ratio M-H, Fixed, 95% CI
Bressan et al[19]	0	34	1	39	100%	0.38 [0.02, 9.05]
Canullo et al[13]	0	15	0	10		Not estimable
Total (95% CI)		**49**		**49**	**100%**	**0.38 [0.02, 9.05]**
Total events	0		1			

Heterogeneity: Not applicable

Test for overall effect: Z = 0.60 (*P* = 0.55)

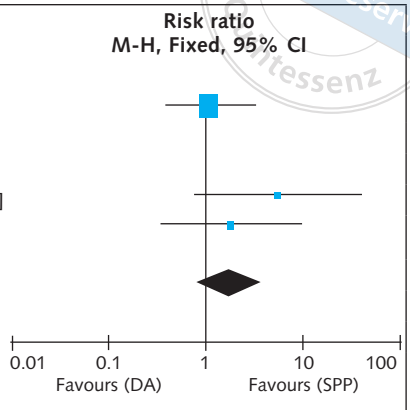
b



Study or sub-group (follow-up duration, months)	DA Events	DA Total	SPP Events	SPP Total	Weight	Risk ratio M-H, Fixed, 95% CI
Bressan et al[19] (12)	6	38	6	40	67.7%	1.05 [0.37, 2.98]
Canullo et al[13] (18)	0	15	0	10		Not estimable
Grandi et al[14] (12)	0	14	0	14		Not estimable
Grandi et al[17] (12)	5	12	1	13	11.1%	5.42 [0.73, 39.97]
Molina et al[20] (12)	3	16	2	19	21.2%	1.78 [0.34, 9.38]
Total (95% CI)		**95**		**96**	**100%**	**1.69 [0.78, 3.66]**
Total events	14		0			

Heterogeneity: Chi² = 2.10; df = 2 (*P* = 0.35); I² = 5%

Test for overall effect: Z = 1.33 (*P* = 0.18)

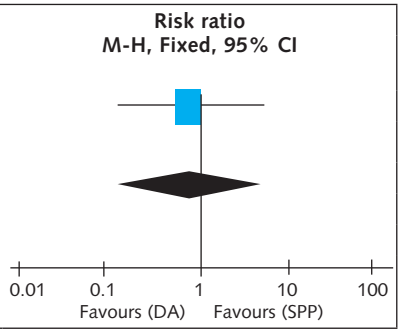


a

Study or subgroup	DA Events	DA Total	SPP Events	SPP Total	Weight	Risk ratio M-H, Fixed, 95% CI
Bressan et al[19]	2	34	3	39	100%	0.76 [0.14, 4.31]
Canullo et al[13]	0	15	0	10		Not estimable
Total (95% CI)		**49**		**49**	**100%**	**0.76 [0.14, 4.31]**
Total events	2		3			

Heterogeneity: Not applicable

Test for overall effect: Z = 0.30 (*P* = 0.76)



b

Fig 5a-b Forest plot for 'complications' at different follow-up periods: **(a)** 12 to 18 months after; **(b)** 36 months after. DA, definitive abutment; SPP, standard prosthetic protocol.

presented crown mobility due to screw loosening. Also, one patient from the SPP group in the study by Grandi et al[17] presented abutment screw loosening. In the study by Bressan et al[19] nine patients had complications: four patients in the SPP group had nine complications; and five patients in the definitive abutment group had eight complications. Complications in the SPP group included one alveolar infection, and a palatal wound dehiscence in implant 23 (according to FDI notation); this same patient developed peri-implantitis in implant 25 at a later stage. This same implant (25) fractured at the 3-year follow-up. A fistula was observed at the time of the definitive crown delivery, which disappeared after the definitive abutment was disconnected and cleaned. In this same patient the definitive abutment unscrewed and was rescrewed into place. The same crown debonded and was cemented again. Complications in the definitive abutment group described by Bressan et al[19] included: three debondings of the provisional restorations in one patient; two debondings of a single crown in another patient; peri-implant mucositis with local swelling in a patient with bleeding 9 months after the delivery of the definitive restoration; and two definitive prosthesis debonded in two other patients.

In the study by Grandi[17], one patient from the definitive abutment group developed peri-implant mucositis. Also, excess of cement in four patients of the definitive abutment group was observed and the procedure to remove the cement was described as difficult and time consuming[17]. A total of four trials reported the occurrence of complications, and there were no significant differences in the complication rate between the two groups at the 12- to 18-month follow-up (*P* = 0.18, RR: 1.69, 95% CI: 0.78 to 3.66). Furthermore, at the 3-year follow-up the forest plot revealed no significant differences between the two groups (*P* = 0.76, RR: 0.76, 95% CI: 0.14 to 4.31) (Fig 5).

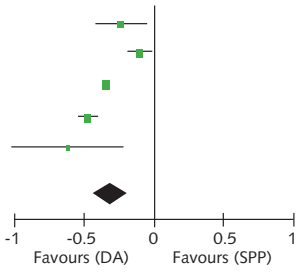
Marginal bone loss (MBL)

The five studies included in the present MBL meta-analysis used periapical radiographs to measure

Study or sub-group (follow-up duration, months)	DA Mean	DA SD	DA Total	SPP Mean	SPP SD	SPP Total	Weight	Mean difference IV, Random, 95% CI
Bressan et al[19] (12)	0.09	0.2	38	0.33	0.53	40	17.8%	-0.24 [-0.42, -0.06]
Canullo et al[13] (18)	0.33	0.08	15	0.43	0.12	10	23.8%	-0.10 [-0.18, -0.02]
Grandi et al[14] (12)	0.094	0.025	14	0.435	0.025	14	26.3%	-0.34 [-0.36, -0.32]
Grandi et al[17] (12)	0.108	0.063	12	0.583	0.111	13	24.6%	-0.47 [-0.55, -0.40]
Molina et al[20] (12)	0.59	0.322	16	1.21	0.816	19	7.5%	-0.62 [-1.02, -0.22]
Total (95% CI)			**95**			**96**	**100%**	**-0.32 [-0.45, -0.19]**
Total events								

Heterogeneity: $Tau^2 = 0.02$; $Chi^2 = 48.23$; df = 4 ($P < 0.00001$); $I^2 = 92\%$

Test for overall effect: Z = 4.84 ($P < 0.00001$)

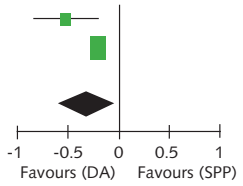


a

Study or subgroup	DA Mean	DA SD	DA Total	SPP Mean	SPP SD	SPP Total	Weight	Mean difference IV, Random, 95% CI
Bressan et al[19]	0.11	0.2	34	0.64	1	39	37.5%	-0.53 [-0.85, -0.21]
Canullo et al[13]	0.34	0.07	15	0.55	0.09	10	62.5%	-0.21 [-0.28, -0.14]
Total (95% CI)			**49**			**49**	**100%**	**-0.33 [-0.63, -0.03]**
Total events								

Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 3.66$; df = 1 ($P = 0.06$); $I^2 = 73\%$

Test for overall effect: Z = 2.13 ($P = 0.03$)



b

Fig 6a-b Forest plot for 'marginal bone loss' at different follow-up periods: **(a)** 12 to 18 months; **(b)** 36 months. DA, definitive abutment; SPP, standard prosthetic protocol.

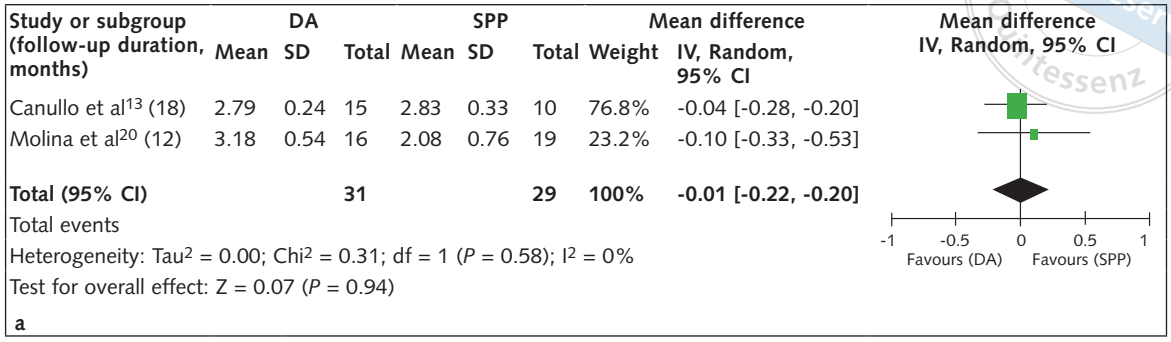
the distance between the implant shoulder and the nearest implant-to-bone contact, and the baseline was at the time of implant placement[13,14,17,19,20]. The MBL meta-analysis between groups was conducted using a random-effects model in accordance with the high heterogeneity observed ($I^2 = 92\%$, $P < 0.00001$). A MD of –0.32 mm (95% CI –0.45 to –0.19 $P < 0.00001$) was calculated, with a statistically significant difference in favour of the definitive abutment group at 12 to 18 months. Also, at the 3-year follow-up the meta-analysis of two trials showed a significant statistical difference in favour of the definitive abutment group ($I^2 = 73\%$, $P = 0.03$; MD: –0.33 mm, 95% CI: –0.63, –0.03) (Fig 6).

Aesthetic outcomes

Bressan et al[19] used the pink aesthetic score (PES)[25] to evaluate aesthetic outcomes; the difference between groups was not statistically significant considering the average PES. However, when evaluating the single aesthetic domain, at the 3-year follow-up, one domain showed a statistically significant difference; the soft tissue contour for the definitive abutment (DA) group scored better than the SPP group (DA = 1.88, SPP = 1.79; difference = 0.26, $P = 0.015$). Molina et al[20] used digital photographs with the aid of a manual periodontal probe to assess soft tissue changes and the papilla index[26] to assess the papilla fill. No significant differences were found between the groups (SPP: 0.706 ± 0.931 and DA: 0.365 ± 1.027; $P = 0.617$).

Probing depth

Two studies[13,20] monitored the probing depth around implants. The meta-analysis showed no statistical difference between the groups (MD of –0.01 95% CI: –0.22 to 0.20; $P = 0.94$) at 12 to 18 months and at 36 months (Fig 7). The values collected for the probing depth in both groups were considered to be within parameters of peri-implant health[27].



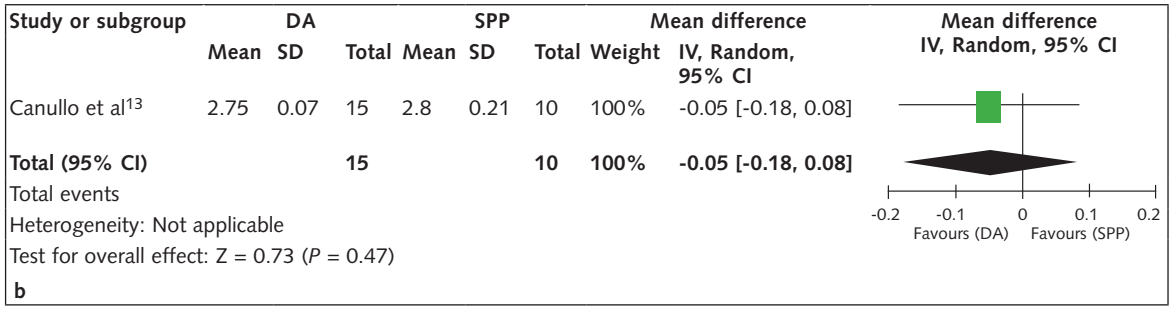


Fig 7a-b Forest plot for 'probing depth' at different follow-up periods: **(a)** 12 to 18 months; **(b)** 36 months. DA, definitive abutment; SPP, standard prosthetic protocol.

Discussion

Summary of the main results

The aim of this review was to assess the MBL around implants restored with the use of a definitive abutment at the time of implant placement and implants restored with the standard prosthetic protocol (SPP), which requires multiple changes of abutments. The outcome measures investigated included implant and prosthetic failure, complications, marginal bone level changes, probing depth, and aesthetics. The results of the present review revealed no significant differences between the two interventions (definitive abutment versus SPP) regarding implant failure, prosthetic failures, complications and probing pocket depths. The implant success rate was high for both groups in all studies included without statistically significant difference between the groups.

There was a statistically significant difference of 0.3 mm after the 3-year follow-up in two trials, which favoured the definitive abutment group in regards to MBL changes; this suggests that the use of a definitive abutment could minimise MBL around implants. Regarding the aesthetic outcome, there was not sufficient evidence to determine whether there were advantages in using the 'one abutment – one time' approach. In the two studies[19,20] that measured aesthetics no significant differences were found between the groups. The study by Bressan et al[19] that used a more comprehensive method (PES), found a significant difference only when isolating a specific aesthetic domain, namely the soft tissue contour, which again favoured the definitive abutment group.

Overall completeness and applicability of evidence

All studies reported cases of implant and prosthetic failure, complications and marginal bone level changes. Two studies reported aesthetic outcomes; however, the methods varied between studies, which made a statistical comparison difficult[19,20]. Two studies evaluated probing depth and found no statistical significant difference ($P = 0.64$) between groups[13,20]. These measurements were in agreement with the values of healthy peri-implant tissues described in the literature[27].

The present review included five RCTs that evaluated the clinical outcomes of two different prosthetic protocols: the use of a definitive

abutment versus a SPP. The number of abutment exchanges performed by the studies varied from two to four times; yet all studies reported a statistically significant reduction in bone loss in the definitive abutment group.

Despite the positive effect of using a definitive abutment on the marginal bone, the clinical relevance of the observed bone remodelling difference is still unclear. Furthermore, it should be noted that the use of a definitive abutment often results in a cement-retained prosthesis. In these cases, when selecting a definitive abutment the bone and soft tissue remodelling should be taken into consideration to avoid deep cementation margins. One study[14] reported excess of cement in four patients in the definitive abutment group. Therefore, meticulous cementation procedures are advised when using a definitive abutment since excess of cement is considered a risk factor for peri-implantitis[28].

Quality of evidence

The risk of bias was high in most studies[13,14,17,19]. The present systematic review has some limitations, such as the small number of studies included and significant heterogeneity observed between studies. Also, the number of abutment changes in the SPP group varied between studies, which could be considered a confounding factor. The present review provided insufficient evidence regarding aesthetic outcomes since only three studies reported results related to this outcome and used different methods in their measurements. The sample size was small in all studies and only three studies reported sample size calculation[13,19,20]. In addition, the follow-up periods were short, ranging from 12 to 36 months. Thus, the data from this meta-analysis of RCTs cannot be generalised.

Conclusions

The data presented by the studies included in this review suggest that repeated changes of abutment can cause an increase in peri-implant MBL of about 0.3 mm. The complications reported in both groups were common with no high risk of complication associated with a specific group. All studies showed a high implant survival rate. The aesthetic evaluation did not show statistically significance difference between groups. The positive effect of using a definitive abutment on the marginal bone should be interpreted with caution since the clinical relevance of the observed difference is unclear.

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