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Abutment Disconnection/Reconnection Affects Peri-implant Marginal Bone Levels: A Meta-Analysis

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Purpose: *Preclinical and clinical studies have shown that marginal bone loss can be secondary to repeated disconnection and reconnection of abutments that affect the peri-implant mucosal seal. The aim of this systematic review and meta-analysis was to evaluate the impact of abutment disconnections/reconnections on peri-implant marginal bone level changes.* ***Materials and Methods:*** *To address this question, two reviewers independently performed an electronic search of three major databases up to October 2015 complemented by manual searches. Eligible articles were selected on the basis of prespecified inclusion and exclusion criteria after a two-phase search strategy and assessed for risk of bias. A random-effects meta-analysis was performed for marginal bone loss.* ***Results:*** *The authors initially identified 392 titles and abstracts. After evaluation, seven controlled clinical studies were included. Qualitative assessment of the articles revealed a trend toward protective marginal bone level preservation for implants with final abutment placement (FAP) at the time of implant placement compared with implants for which there were multiple abutment placements (MAP). The FAP group exhibited a marginal bone level change ranging from 0.08 to 0.34 mm, whereas the MAP group exhibited a marginal bone level change ranging from 0.09 to 0.55 mm. Meta-analysis of the seven studies reporting on 396 implants showed significantly greater bone loss in cases of multiple abutment disconnections/reconnections. The weighted mean difference in marginal bone loss was 0.19 mm (95% confidence interval, 0.06–0.32 mm), favoring bone preservation in the FAP group.* ***Conclusion:*** *Within the limitations of this meta-analysis, abutment disconnection and reconnection significantly affected peri-implant marginal bone levels. These findings pave the way for revisiting current restorative protocols at the restorative treatment planning stage to prevent incipient marginal bone loss.*
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Keywords: *bone loss, dental abutments, dental implants, follow-up studies, osseointegration, titanium*

The establishment and maintenance of a soft tissue seal around dental implants is essential for implant success. The average dimensions of the peri-implant soft tissues are well established: an average of 2 mm of long barrier epithelium and 1 to 1.5 mm of connective tissue integration zones.[1–4]

Any factor that disturbs the connective tissue interaction area has the potential to influence peri-implant bone levels.[1] Dental implant therapy protocols often involve repeated removal and replacement of healing abutments and/or provisional restorations before delivery of a final prosthesis. Several studies have assessed whether a series of abutment disconnections/reconnections can affect the mucosal barrier and result in marginal bone loss; the outcomes have been conflicting.[5–8] Initially, Abrahamson et al[5] reported a more apically positioned connective tissue zone on implants (external hex configuration) subsequent to a series of five abutment disconnections/reconnections. In a later study,[6] the same group used implants with an internal conical connection and reported that a single abutment disconnection/reconnection did not influence the amount of bone resorption or the quality or dimensions of the transmucosal attachment. In a more

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Table 1 Optimization of Keyword Combinations with Boolean Operators Used in the Ovid MEDLINE Search (October 2015)

Advanced search in Ovid MEDLINE	No. of articles
1. exp Dental Implantation, Endosseous/	14,291
2. ((endosseous adj4 implant*) or (osseo-integrated adj4 dental adj4 implant*)).tw.	2,432
3. 1 or 2	15,144
4. Dental Implants/	15,247
5. ((dental adj4 implant*) or (surgical adj4 dental adj4 prosthe*)).tw.	11,007
6. 4 or 5	20,798
7. Dental Implant-Abutment Design/	576
8. (implant* adj4 abutment* adj4 (design* or connection* or interface*)).tw.	570
9. (platform adj4 (switch or switched or switching or (match or matched or matching))).mp.	324
10. ((tooth or teeth or dent*) and (morse adj4 (taper$ or connection$))).mp.	111
11. dental journals.sb. and morse taper.mp.	101
12. 7 or 8 or 9 or 10 or 11	1,291
13. 3 or 6 or 12	27,292
14. (detach* or disconnect* or reattach* or reconnect* or remov* or replac*).mp.	920,019
15. Alveolar Bone Loss/	8,208
16. ((alveola* or periodont*) adj4 bone* adj4 (loss* or losses* or lose or losing or lost or atroph* or resorp* or resorb*)).tw.	3,182
17. 15 or 16	9,927
18. 13 and 14 and 17	739
19. randomized controlled trial.pt.	417,389
20. controlled clinical trial.pt.	92,255
21. randomized.ab.	339,054
22. placebo.ab.	170,033
23. drug therapy.fs.	1,860,741
24. randomly.ab.	244,720
25. trial.ab.	353,117
26. groups.ab.	1,523,039
27. 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26	3,708,448
28. exp animals/not humans.sh.	4,152,952
29. 27 not 28	3,190,304
30. 18 and 29	152

recent study, Becker et al[7] reported that disruption of the peri-implant mucosal seal resulted in subsequent bone loss when abutments were disconnected and then reconnected twice from internal conical connection implants. In this study, titanium dioxide and zirconium dioxide exhibited similar peri-implant tissue responses to abutment disconnection/reconnection. In contrast to those findings, Alves et al[8] reported that a five-time abutment disconnection/reconnection failed to affect marginal bone resorption for implants with an internal conical connection. However, the authors concluded that abutment disconnections/reconnections can affect the dimensions of the buccal peri-implant mucosa and may induce greater marginal bone loss when thin biotypes are present.

To the authors' knowledge, a meta-analysis of studies evaluating the impact of abutment disconnection/reconnection on peri-implant marginal bone loss in humans has not been conducted. Thus, the aim of this systematic review and meta-analysis was to evaluate the impact of abutment disconnection/reconnection on peri-implant marginal bone level changes.

MATERIALS AND METHODS

Search Strategy

The authors used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines as a basis for developing a specific question, according to the participants, interventions, comparison, outcomes (PICO) principle[9]:

- Participants (P)—Subjects participated in studies that involved implant rehabilitation with a fixed prosthesis.
- Types of interventions (I)—Connection of final abutment at the time of implant placement without subsequent disconnection.
- Comparison intervention (C)—Multiple healing abutment disconnections/reconnections before placement of the final abutment.
- Outcome (O)—Changes in marginal bone levels.

In October 2015, a medical librarian (J.R.) conducted an electronic search that addressed the PICO parameter in databases including Ovid MEDLINE (1946–2015), Elsevier Embase (1947–2015), and EBSCO CINAHL (1937–2015). Articles published in electronic format ahead of print were considered eligible for inclusion.

The search of electronic databases used both Medical Subject Heading (MeSH) terms and free text associated with implant therapy and abutment disconnection/reconnection (implant, abutment, bone loss). Table 1 outlines the Ovid MEDLINE search strategy.

Selection Criteria

Two reviewers (TK, FG) conducted screenings independently and in duplicate for both phases of the search. For the first phase, titles and abstracts were screened on the basis of the following criteria: original articles; human controlled clinical studies; ≥ 10 participants; ≥ 3 months of follow-up after the intervention; and surgical interventions such as implant placement with multiple abutment replacements before placement of the final abutment, and implant placement with final abutment placement (FAP) at the same time. Exclusion criteria were review articles, case series, case reports, and animal studies.

When at least one reviewer found a study to be potentially relevant, the full-text articles were acquired and evaluated against the inclusion criteria for eligibility. In addition, full-text articles for each of the referenced studies within the articles previously deemed relevant were also reviewed. The two reviewers performed an additional evaluation independently and in duplicate; κ scores (Cohen's κ coefficient) were estimated to evaluate the level of inter-reviewer agreement.[10]

Data Extraction

Both reviewers (T.K., F.G.) independently acquired data pertaining to the following parameters: publication year, data location, source of funding, patient characteristics, number of implants in each group, characteristics of the implants, number of abutment disconnections, inclusion of smokers, timing of implant placement, follow-up time, and marginal bone level changes. The data for each study were reviewed and entered into electronic spreadsheets.

Outcome Variables

The impact of abutment disconnection/reconnection on marginal bone level changes was studied as the primary outcome variable.

Assessment of Bias Within Studies

The two reviewers (T.K., F.G.) used a specific protocol to evaluate the studies. Because one of the reviewers was the author of one of the included studies, an independent expert (V.C.), who was not an author, assessed the risk of bias for the study by Koutouzis et al. Because this review included only controlled clinical trials, the authors used a domain-based evaluation, as recommended in the Cochrane Handbook.[11] For each study, a cumulative score was estimated and the overall risk of bias was evaluated for the included randomized clinical trials.[11] A low risk of bias was assigned to studies that fulfilled all criteria. A moderate risk of bias was assigned to studies in which at least one criterion was only partially fulfilled. A high risk of bias was assigned to studies in which one or more criteria were not fulfilled.[12]

Statistical Analyses

The authors performed a meta-analysis with marginal bone level as the primary outcome. The mean difference in marginal bone level changes between implants with FAP and implants with MAP was estimated as the effect-size measure. The q statistic and I^2 statistic were used to evaluate heterogeneity among the included studies.[13]

The authors used the DerSimonian-Laird method to combine outcome measures with a random-effects model.[14] Forest plots were formulated to report the weighted average of outcome and 95% confidence intervals (CIs). The α level was set at .05. Construction of funnel plots was not done because of the small number of included studies.[11] All statistical analyses were performed with the use of statistical software (R metaphor package, R Development Core Team).

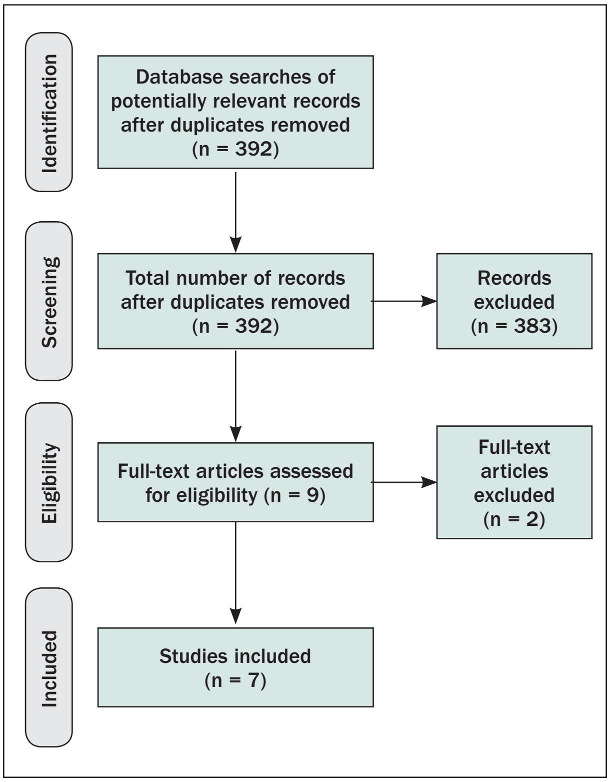

Fig 1 Flowchart showing study selection based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

RESULTS

The initial search revealed 392 article titles and abstracts after duplicates were removed (Fig 1). The authors did not include 383 articles because they were not relevant to the PICO question (κ score for inter-reviewer agreement [95% CI], 0.77 [0.55–0.99]). Further evaluation of the nine remaining full-text articles[15–24] led to the exclusion of two studies.[15,16] One study was excluded because the intervention was outside the review scope,[16] and the second study was an uncontrolled case series.[15] In total, seven controlled clinical studies satisfied the inclusion criteria.[17–24] All studies reported changes in peri-implant marginal bone level as an outcome.

Risk of Bias Assessment

The authors identified one study[23] as having a low risk of bias and one study as having a moderate risk of bias.[22]

Table 2 Assessment of Risk of Bias Among Included Studies

Source of potential bias	Canullo et al[17]	Degidi et al[18]	Grandi et al[19]	Koutouzis et al[20]	Grandi et al[21]	Degidi et al[22]	Luongo et al[23]
Random sequence generation	Low risk	High risk	Low risk	Low risk	Low risk	Low risk	Low risk
Allocation concealment	High risk	High risk	High risk	High risk	High risk	Unclear	Low risk
Blinding of outcome assessment	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Incomplete outcome data	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Selective reporting	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Group imbalance	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk

Table 3 Main Characteristics of Studies Included After Second Phase of Selection

Study	Year	Design	Funding	Implant manufacturer	No. of abutment disconnections	Inclusion of smokers	Timing of implant placement	Follow-up time after implant placement (mo)
Canullo et al[17]	2010	RCT	NA	Sweden & Martina	Unclear	Yes	Immediate	36
Degidi et al[18]	2011	CT	NA	Dentsply	4	Yes	Delayed	36
Grandi et al[19]	2012	RCT	NA	JDentalCare	4	Yes	Delayed	12
Koutouzis et al[20]	2013	RCT	Implant manufacturer (Straumann)	Straumann	2	Yes	Delayed	6
Grandi et al[21]	2014	RCT	NA	JDentalCare	3	Yes	Immediate	12
Degidi et al[22]	2014	RCT	NA	Dentsply	4	Yes	Immediate	24
Luongo et al[23]	2015	RCT	NA	Dentsply	3	Yes	Immediate and delayed	7

NA = not available; RCT = randomized controlled trial; CT = controlled trial.

Table 4 Outcome Assessment of Included Studies

			Mean ± SD MBL change (mm)	
Study	MAP	FAP	MAP	FAP
Canullo et al[17]	10	15	0.55 ± 0.09	0.34 ± 0.07
Degidi et al[18]	24	24	0.15 ± 0.28	0.07 ± 0.27
Grandi et al[19]	28	28	0.43 ± 0.02	0.09 ± 0.02
Koutouzis et al[20]	11	10	0.28 ± 0.16	0.13 ± 0.20
Grandi et al[21]	26	24	0.58 ± 0.11	0.11 ± 0.06
Degidi et al[22]	35	33	0.75 ± 0.11	0.71 ± 0.1
Luongo et al[23]	70	58	0.09 ± 0.2	0.08 ± 0.16

SD = standard deviation; MAP = multiple abutment placements; FAP = final abutment placement; MBL = marginal bone level.

The remaining five studies were identified as having a high risk of bias.[17–21] For these five studies, at least four methodologic criteria were fully or partially met (Table 2).

Qualitative and Quantitative Results

Six of the seven included studies were randomized controlled clinical studies,[17,19–23] and one study was a controlled clinical trial.[18] Overall, 266 patients with a total of 396 implants were included. Participants' ages ranged from 30 to 85 years, and the postplacement follow-up time ranged from 6 to 36 months. Various implant connections and surfaces were used, and all studies used implants with platform-switching features. Three studies[18,19,22] evaluated groups with four abutment disconnections/reconnections before final abutment placement, two studies[21,23] evaluated three abutment disconnections/reconnections, one study[20] evaluated two disconnections/reconnections, and for one study,[17] the number of abutment disconnections/reconnections was not clear (Table 3). All studies reported marginal bone level changes from implant placement to the last follow-up examination. Two studies[20,22] reported peri-implant mucosal dimensional changes, one study[20] reported probing depths and bleeding on probing, and one study reported patient satisfaction.[23]

Overall, there was a trend toward marginal bone level preservation in the FAP group in all seven studies (Table 4). The marginal bone level change ranged from 0.09 mm[23] to 0.55 mm[17] for the MAP group and from 0.08 mm[23] to 0.34 mm[17] for the FAP group.

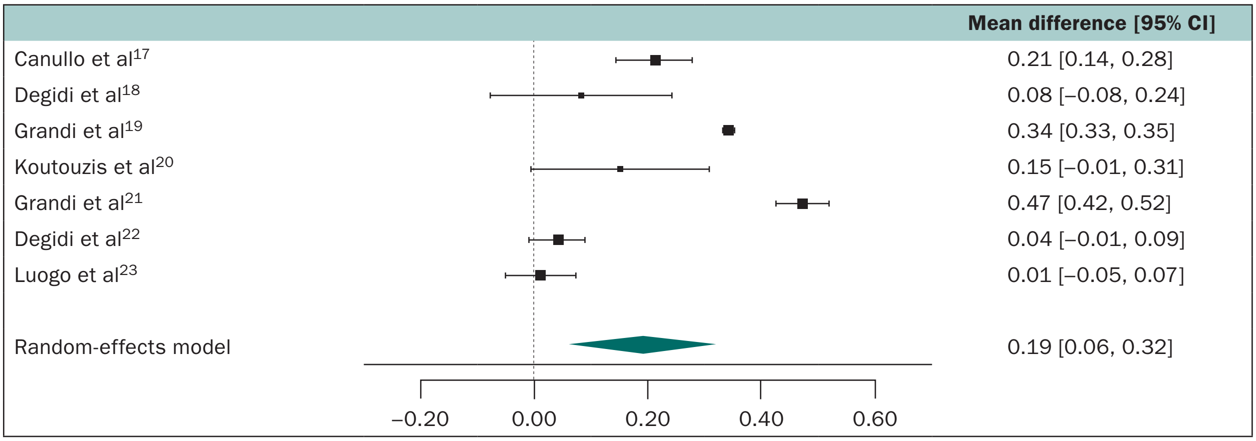

Fig 2 Forest plot of random-effects meta-analysis of the marginal bone level outcome.

The authors assessed seven studies[17–24] in the meta-analysis (Fig 2). Tests for heterogeneity demonstrated considerable heterogeneity ($df = 6$, $I^2 = 97\%$, $tau^2 = 0.17$); therefore, a random-effects model was used for the analysis. Random-effects meta-analysis of the seven studies showed an increase in mean (95% CI) marginal bone loss of 0.19 mm (0.06–0.32 mm).

DISCUSSION

The results of the present meta-analysis demonstrated that multiple abutment disconnections/reconnections could have a modest effect on marginal bone level changes. More specifically, comparisons of weighted estimates among the included studies demonstrated a 0.19-mm greater mean marginal bone level change for implants treated with multiple abutment disconnections/reconnections.

The effect of abutment disconnection/reconnection on marginal bone level changes has been evaluated in experimental studies showing that the number of abutment disconnections/reconnections may have an impact on the amount of marginal bone loss.[5,6] In the current meta-analysis, two of the studies that reported the greatest mean differences in marginal bone levels between implants with MAP and implants with FAP had three[21] and four[19] abutment disconnections/reconnections. Thus, in cases in which abutment disconnection/reconnection cannot be avoided, the adoption of treatment protocols that minimize the number of abutment disconnections/reconnections may be beneficial in terms of marginal bone level preservation.

The treatment protocols for the included studies differed in several ways. Some differences involved the timing of implant placement, location of the implant platform relevant to the alveolar crest, flap reflection, and use of bone graft material. All studies included smokers in both groups. Despite differences in treatment protocols, all studies demonstrated a trend toward a protective effect on marginal bone level for the FAP group. Thus, limiting the number of abutment disconnections/reconnections seems to be beneficial regardless of the treatment protocol.

All included studies used abutments with a similar design for the FAP group. Thus, prefabricated abutments with a round margin were mainly used. Prefabricated abutments commonly have submucosal margin placement, which may have an effect on the cementation process. Positioning the abutment margin in the submucosal region increases the amount of undetected cement.[24] One of the primary difficulties in securing the final abutment at implant placement is the uncertainty of the final mucosal margin location in relation to the margin of the abutment at prosthesis delivery. Screw-retained restorations may be preferable for this treatment concept, thus eliminating the risk of leaving undetected cement submucosally. Use of custom abutments at the time of implant placement may be a valid alternative in the future, given the prerequisite that accurate fabrication of the custom abutment based on a planned implant position is possible, and if the predicted peri-implant mucosal level change is taken into consideration.

Implants in the FAP groups were subjected to immediate loading conditions. In a systematic review[25] comparing immediate versus conventional loading, the researchers reported that patients with conventionally loaded implants lost a mean of 0.1 mm more peri-implant marginal bone than patients with implants subjected to immediate loading. This finding is in line with the findings of the present meta-analysis. In a histomorphometric evaluation of the peri-implant soft tissues around immediately loaded implants in the human mandible, the authors suggested that refraining from abutment removal played a role in favorable healing.[26]

Two of the included studies reported outcomes in terms of peri-implant mucosal level changes.[20,22] In a study of posterior implants, Koutouzis et al[20] reported an apical repositioning of the peri-implant mucosa between the 2-week and 2-month follow-up examinations at all implant sites. Subsequently, the authors noted a smaller coronal peri-implant shift between the 3-month crown placement appointment and the 6-month follow-up examination. No statistically significant differences were found between implants subjected to multiple abutment disconnections/reconnections and implants subjected to the "one abutment, one time" approach. In the study by Degidi et al,[22] the amount of buccal recession was similar between the two treatment groups at the 6-month follow-up, but significantly greater recession occurred in the group with multiple abutment disconnections/reconnections at the 24-month examination. In an animal experiment, Alves et al[8] reported a greater apical shift of the peri-implant mucosal margin position in areas with thin biotype after five abutment disconnections/reconnections. Interestingly, this outcome was not accompanied by greater marginal bone level changes. The authors reported that the increased recession was mainly due to reduction of the connective tissue portion of the peri-implant mucosa resulting from abutment manipulation.

Risk of bias assessment revealed that five[17–21] of the seven studies had insufficiencies in allocation concealment. As expected, the only nonrandomized study[18] had the highest overall risk of bias. Only one study had a low risk of bias for all potential sources evaluated.[23]

Findings of the present meta-analysis should be interpreted critically because of two limitations: *(1)* as mentioned in the Results section, publication bias could not be assessed via funnel plots because fewer than 10 studies were included; thus, we do not know whether studies with large negative findings, which are more likely to suffer from publication bias, might have modified the observed results; *(2)* the meta-analysis is a means of summarizing the results of existing studies, but based on prevailing analytical approaches it does not consider risk of bias in study weighting. The fact that not all included studies were free of bias, as reported in the Results section, warrants careful interpretation.

CONCLUSIONS

Within the limitations of this meta-analysis, abutment disconnection and reconnection significantly affected peri-implant marginal bone levels. This information paves the way to revisit current restorative protocols at the restorative treatment planning stage to prevent incipient marginal bone loss.

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