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Review

Platform switch and dental implants: A meta-analysis

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ABSTRACT

Objectives: To test the null hypothesis of no difference in the implant failure rates, marginal bone loss (MBL) and postoperative infection in patients who received platform-switched implants or platform-matched implants, against the alternative hypothesis of a difference.
Data: Main search terms used in combination: dental implant, oral implant, platform switch, switched platform, platform mismatch, and dental implant–abutment design.
Sources: An electronic search without time or language restrictions was undertaken in December/2014 in PubMed/Medline, Web of Science, Cochrane Oral Health Group Trials Register plus hand-searching.
Study selection: Eligibility criteria included clinical human studies, either randomized or not.
Results: Twenty-eight publications were included, with a total of 1216 platform-switched Q3 implants (16 failures; 1.32%) and 1157 platform-matched implants (13 failures; 1.12%).
Conclusions: There was less MBL loss at implants with platform-switching than at implants with platform-matching (mean difference −0.29, 95% CI −0.38 to −0.19; $P < 0.00001$). An increase of the mean difference of MBL between the procedures was observed with the increase in the follow-up time ($P = 0.001$) and with the increase of the mismatch between the implant platform and the abutment ($P = 0.001$). Due to lack of satisfactory information, meta-analyses for the outcomes 'implant failure' and 'postoperative infection' were not performed. The results of the present review should be interpreted with caution due to the presence of uncontrolled confounding factors in the included studies, most of them with short follow-up periods.
Clinical significance: The question whether platform-matched implants are more at risk for failure and loose more marginal bone than platform-switched implants has received increasing attention in the last years. As the philosophies of treatment alter over time, a periodic review of the different concepts is necessary to refine techniques and eliminate unnecessary procedures, forming a basis for optimum treatment.

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1. Introduction

Q4 One reference criterion to evaluate implant success includes the assessment of changes in crestal bone level over time.[1] After a two-piece implant is uncovered, bone loss of 1.5–2 mm in the vertical axis and 1.4 mm in the horizontal axis was expected with respect to micro-gap (the implant–abutment interface).[2] This pattern of bone loss is usually noted when submerged dental implants are restored using a matched abutment and implant platform. An abutment with a smaller diameter than that of the implant platform (an approach known as platform switching) was first observed in the mid-1980s, when larger-diameter implants were often restored with narrower abutments because congruent abutments were often unavailable.[3] A radiographic follow-up study has found that the placement of platform-switched implants resulted in a smaller vertical change in the crestal bone level than was commonly seen when restoring conventional implants with abutments of matching diameter.[4]

The main hypothesis raised in the literature to explain this phenomenon is the fact that the platform-switching concept requires the implant–abutment interface be placed away from the implant shoulder and closer towards the axis to increase the distance of the microgap from the bone,[4] and thereby decrease its bone resorptive effect[5] caused by the bacterial microleakage.

Researchers have been trying to evaluate whether the insertion of implants receiving abutment with a switched platform may influence the survival of dental implants and the marginal bone level (MBL). However, some studies may lack statistical power, given the small number of patients per group in the clinical trials comparing the techniques. Recent reviews[6,7] showed a significantly less mean MBL change at implants with a platform-switched compared to a platform-matched configuration. However, the authors stressed that the studies included were of relatively short follow-up periods. Moreover, only prospective controlled studies were included, limiting the number of eligible papers. Adding more information from observational studies may aid in clinical reasoning and establish a more solid foundation for causal inferences.[8]

The ability to anticipate outcomes is an essential part of risk management in an implant practice. Recognizing conditions that place the patient at a higher risk of failure will allow the surgeon to make informed decisions and refine the treatment plan to optimize the outcomes.[9] The use of implant therapy in special populations requires consideration of potential benefits to be gained from the therapy. To better appreciate this potential, we conducted a systematic review and meta-analysis of both prospective and retrospective studies to compare the survival rate of dental implants, postoperative infection, and MBL of platform-switched and platform-matched dental implants. The MBL between the two approaches was also compared in relation to different observation periods.

2. Materials and methods

This study followed the PRISMA Statement guidelines.[10] A review protocol does not exist.

2.1. Objective

The purpose of the present review was to test the null hypothesis of no difference in the implant failure rates, MBL and postoperative infection in patients who received platform-switched implants or platform-matched implants, against the alternative hypothesis of a difference. The focused question was elaborated by using the PICO format (Participants, Interventions, Comparisons and Outcomes): to compare three outcomes (implant failure rates, MBL, and postoperative infection) of clinical studies including patients undergoing implant-prosthetic rehabilitation comparing endosseous implants with platform switching and platform-matching implant–abutment configurations.

2.2. Search strategies

A structured electronic systematic search without time or language restrictions was undertaken in December 2014 in the following databases: PubMed/Medline, Web of Science, and the Cochrane Oral Health Group Trials Register. The following terms were used in the search strategy on PubMed/Medline, refined by selecting the term:

{Subject AND Adjective}
{*Subject*: (dental implant OR oral implant [text words])
AND
Adjective: (platform switch OR platform switching OR switched platform OR platform switched OR platform mismatch OR dental implant-abutment design [text words])}

The following terms were used in the search strategy on Web of Science, in all databases:

{Subject AND Adjective}
{*Subject*: (dental implant OR oral implant [topic])
AND
Adjective: (platform switch OR platform switching OR switched platform OR platform switched OR platform mismatch OR dental implant-abutment design [topic])}

The following terms were used in the search strategy on the Cochrane Oral Health Group Trials Register:

(dental implant OR oral implant AND (platform switch OR platform switching OR switched platform OR platform switched OR platform mismatch OR dental implant-abutment design))

A manual search of dental implants-related journals, including *British Journal of Oral and Maxillofacial Surgery*, *Clinical Implant Dentistry and Related Research*, *Clinical Oral Implants Research*, *European Journal of Oral Implantology*, *Implant Dentistry*, *International Journal of Oral and Maxillofacial Implants*, *International Journal of Oral and Maxillofacial Surgery*, *International Journal of Periodontics and Restorative Dentistry*, *International Journal of Prosthodontics*, *Journal of Clinical Periodontology*, *Journal of Dental Research*, *Journal of Craniofacial Surgery*, *Journal of Cranio-Maxillofacial Surgery*, *Journal of Dentistry*, *Journal of Maxillofacial and Oral Surgery*, *Journal of Oral Implantology*, *Journal of Oral and Maxillofacial Surgery*, *Journal of Oral Rehabilitation*, *Journal of Periodontology*,

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Journal of Prosthodontics, *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology*, and *Quintessence International*, was also performed.

The reference list of the identified studies and the relevant reviews on the subject were also scanned for possible additional studies. Moreover, online databases providing information about clinical trials in progress were checked (clinicaltrials.gov; www.centerwatch.com/clinicaltrials; www.clinicalconnection.com).

2.3. Inclusion and exclusion criteria

Eligibility criteria included clinical human studies, either randomized or not, comparing implant failure rates, MBL and/or postoperative infection in any group of patients receiving platform-switched implants or platform-matched implants. For this review, implant failure represents the complete loss of the implant. Exclusion criteria were case reports, technical reports, biomechanical studies, finite element analysis (FEA) studies, animal studies, in vitro studies, and review papers.

2.4. Study selection

The titles and abstracts of all reports identified through the electronic searches were read independently by the three authors. For studies appearing to meet the inclusion criteria, or for which there were insufficient data in the title and abstract to make a clear decision, the full report was obtained. Disagreements were resolved by discussion between the authors.

2.5. Quality assessment

Quality assessment of the studies was executed according to the Newcastle-Ottawa scale (NOS), which is a quality assessment tool to use when nonrandomized studies are also included in systematic reviews, specifically cohort and case–control studies.[11] The NOS calculates the study quality on the basis of three major components: selection, comparability, and outcome for cohort studies. It assigns a maximum of 4 stars for selection, a maximum of 2 stars for comparability, and a maximum of 3 stars for outcome. According to that quality scale, a maximum of 9 stars/points can be given to a study, and this score represents the highest quality, where six or more points were considered high quality.

2.6. Data extraction, meta-analysis and meta-regression

From the studies included in the final analysis, the following data were extracted (when available): year of publication, study design, unicentre or multicentre study, number of patients, patients' age, follow-up, days of antibiotic prophylaxis, mouth rinse, implant healing period, failed and placed implants, postoperative infection, MBL, implant surface modification, type of prosthetic rehabilitation, and jaws receiving implants (maxilla and/or mandible). Contact with authors for possible missing data was performed.

Only randomized clinical trials (RCTs) were considered for the quantitative synthesis (meta-analysis). Implant failure and postoperative infection were the dichotomous outcomes measures evaluated. Weighted mean differences were used to construct forest plots of MBL, a continuous outcome. The statistical unit for 'implant failure' and 'MBL' was the implant, and for 'postoperative infection' was the patient. Whenever outcomes of interest were not clearly stated, the data were not used for analysis. The I^2 statistic was used to express the percentage of the total variation across studies due to heterogeneity, with 25% corresponding to low heterogeneity, 50% to moderate and 75% to high. The inverse variance method was used for random-effects or fixed-effects model. Where statistically significant ($P < 0.10$) heterogeneity is detected, a random-effects model was used to assess the significance of treatment effects. Where no statistically significant heterogeneity was found, analysis was performed using a fixed-effects model.[12] The estimates of relative effect for dichotomous outcomes were expressed in risk ratio (RR) and in mean difference (MD) in millimetres for continuous outcomes, both with a 95% confidence interval (CI). Only if there were studies with similar comparisons reporting the same outcome measures was meta-analysis to be attempted. In the case where no events (or all events) are observed in both groups the study provides no information about relative probability of the event and is automatically omitted from the meta-analysis. In this (these) case(s), the term 'not estimable' is shown under the column of RR of the forest plot table. The software used here automatically checks for problematic zero counts, and adds a fixed value of 0.5 to all cells of study results tables where the problems occur.

In order to explore the possible heterogeneity of effect between studies, a meta-regression was performed in order to verify how a categorical study characteristic is associated with the intervention effects in the meta-analysis, but only when there were at least ten studies available with relevant variables.

A funnel plot (plot of effect size vs. standard error) was drawn. Asymmetry of the funnel plot may indicate publication bias and other biases related to sample size, although the asymmetry may also represent a true relationship between trial size and effect size.

The data were analyzed using the statistical software Review Manager (version 5.3.3, The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark, 2014). Meta-regressions (when possible) were performed by using the software OpenMeta[Analyst].[13]

3. Results

3.1. Literature search

The study selection process is summarized in Fig. 1. The search strategy resulted in 2907 papers. A total of 28 publications were included in the qualitative synthesis and 18 were included in the quantitative synthesis (meta-analysis).

3.2. Description of the studies

Detailed data of the 28 included studies are listed in Tables 1 and 2. Eighteen RCTs,[3,14–30] six controlled clinical trials,[31–36] and four retrospective analyses[37–40] were included. Two

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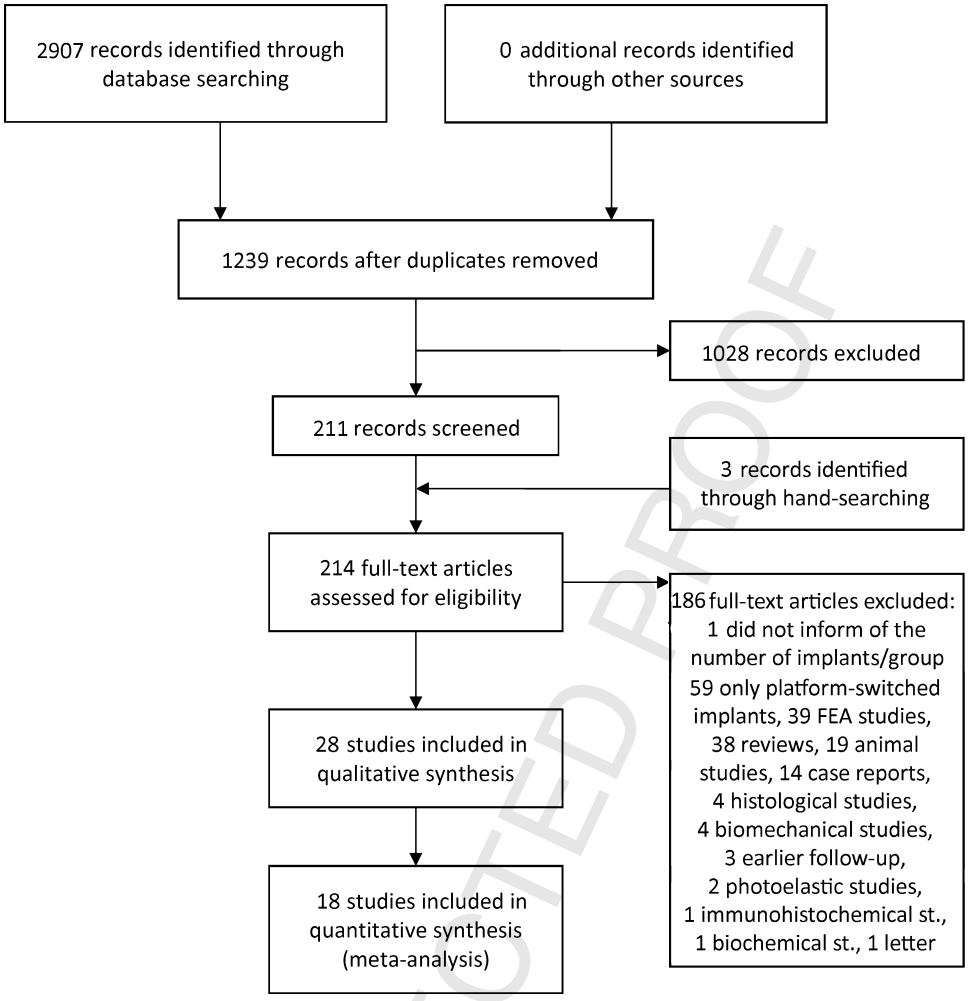

Fig. 1 – Study screening process.

studies[23,38] did not provide the number of implant failures in each group. Of the 26 studies comparing the procedures with this information, a total of 1216 dental implants were platform-switched with the prosthetic abutment, with 16 failures (1.32%), and 1157 implants were platform-matched with the prosthetic abutment, with 13 failures (1.12%). There were no implant failures in 20 studies.[3,14–16,18–20,22,25,27,30–37,39,40]

3.3. *Quality assessment*

Twenty-six studies were of high quality and two were of moderate quality, according to the NOS. The scores are summarized in Table 3.

3.4. *Meta-analysis*

As only six[17,21,24,26,28,29] of the twenty-eight included studies reported events of implant failure and with a small number of occurrences, it was unsuitable to perform a meta-analysis on this outcome. Only six studies[15,16,19,22,27,37] provided information about postoperative infection, with no occurrences. Therefore, meta-analysis for the outcome 'postoperative infection' was not performed.

Eighteen RCTs were included in the meta-analysis for the outcome MBL. There was a significant effect of platform-switched implants on the occurrence of MBL (MD −0.29, 95% CI −0.38 to −0.19; $P < 0.00001$; random-effects model; Fig. 2) in comparison with platform-matched implants. The outcome was also classified in subgroups of different follow-up periods: (a) ≤3 months, (b) 3 months $< t \leq 6$ months, (c) 6 months $<$ time ≤ 1 year, (d) 1 year $< t < 3$ years, and (e) ≥3 years. The results showed an increase of the MD was observed with the increase in the follow-up time (Fig. 2): (a) MD −0.13 ($P = 0.07$), (b) MD −0.11 ($P = 0.003$), (c) MD −0.24 ($P < 0.00001$), (d) MD −0.46 ($P = 0.0004$), and (e) MD −0.60 ($P = 0.01$). The test of heterogeneity among all studies showed heterogeneity ($\tau^2 = 0.08$, $\chi^2 = 461.00$, df = 39; $P < 0.00001$, $I^2 = 92\%$), as well as the test for subgroup differences (inconsistency across the subgroups) ($\chi^2 = 12.49$, df = 4, $P = 0.01$, $I^2 = 68.0\%$).

3.5. *Meta-regression*

Two covariates were considered relevant: the follow-up period and the mismatching between the platform and the abutment. When a plotting considering the follow-up period as a covariate was performed, it was observed an increase of the MD was observed with the increase in the follow-up time ($P = 0.001$;

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Table 1 – Detailed data of the included studies – Part 1.

Authors	Published	Study design	Patients (*n*)	Patients' age range (average) (years)	Follow-up visits (or range)	Antibiotics/ mouth rinse (days)	Healing period/ loading	Failed/ placed implants (*n*)	Implant failure rate (%)	*P* value (for failure rate)	Postoperative infection	Bone level of the implant platform	Abutment/ implant platform (G2; mm)
Hürzeler et al.[14]	2007	RCT (unicentre)	15 (NM)	17–69 (55.3)	1 year	NM	NM	0/14 (G1) 0/8 (G2)	0 (G1) 0 (G2)	No failures	NM	NM	4.1/5.0
Canullo et al.[15]	2009	RCT (multicentre)	22 (11, G1; 11, G2)	32–76 (50)	Mean 25 months (range 24–27)	6/14	Immediate	0/11 (G1) 0/11 (G2)	0 (G1) 0 (G2)	No failures	0 (G1) 0 (G2)	Buccal level of the bone crest	3.8/5.5
Crespi et al.[16]	2009	RCT (unicentre)	45 (NM)	25–67 (48)	2 years	7/15	Immediate	0/30 (G1) 0/34 (G2)	0 (G1) 0 (G2)	No failures	0 (G1) 0 (G2)	Subcrestal (1 mm)	NM
Kielbassa et al.[17]	2009	RCT (multicentre)	177 (117, G1; 60, G2)	17–79 (48.7)	1 year	According to the procedures of each centre	Immediate	7/199 (G1) 3/126 (G2)	3.52 (G1) 2.38 (G2)	NM	NM	NM	NM
Prosper et al.[3]	2009	RCT (multicentre)	60 (20, G1; 40, G2)	25–70 (53.9)	2 years	1/15	6 months (maxilla) 3 months (mandible)	0/120 (G1) 0/240 (G2)	0 (G1) 0 (G2)	No failures	NM	Buccal level of the bone crest	3.3/3.8 3.8/4.5 4.5/5.2
Trammell et al.[18]	2009	RCT (unicentre)	10[a]	NM	2 years	NM	2 months	0/13 (G1) 0/12 (G2)[b]	0 (G1) 0 (G2)	No failures	NM		NM
Vigolo and Givani[31]	2009	CCT (unicentre)	144[a]	25–55 (37)	5 years	NM	4 months	0/97 (G1) 0/85 (G2)	0 (G1) 0 (G2)	No failures	NM	Crestal	NM
Bilhan et al.[37]	2010	RA (unicentre)	51 (NM)	18–86 (59)	3 years	NM	NM	0/75 (G1) 0/51 (G2)[b]	0 (G1) 0 (G2)	No failures	0 (G1) 0 (G2)	NM	NM
Canullo et al.[19]	2010	RCT (multicentre)	31 (NM)	36–78 (52.1)	33 months	6/14	3 months	0/50 (G1) 0/19 (G2)	0 (G1) 0 (G2)	No failures	0 (G1) 0 (G2)	Crestal	3.8/4.3 3.8/4.8 3.8/5.5
Fickl et al.[32]	2010	CCT (unicentre)	36[a]	17–69 (55.3)	1 year	NM	6 months (maxilla) 3 months (mandible)	0/75 (G1) 0/14 (G2)	0 (G1) 0 (G2)	No failures	NM	Subcrestal (5.0 implants, G1) Crestal (4.0 implants, G2)	4.1/5.0
Linkevicius et al.[33]	2010	CCT (unicentre)	4 (NM)	37–56 (43)	1 year	1/7	4 months (maxilla) 2 months (mandible)	0/6 (G1) 0/6 (G2)	0 (G1) 0 (G2)	No failures	NM	NM	NM
Veis et al.[38]	2010	RA (unicentre)	NM	NM	2 years	NM	5–6 months (maxilla) 3–5 months (mandible)	NM/89 (G1) NM/193 (G2)	–	–	NM	Supracrestal, crestal, and subcrestal	4.0/5.0
Canullo et al.[20]	2011	RCT (multicentre)	9 (NM)	50–68 (59)	3 years	"Started 1 day before surgery"	2–3 months	0/17 (G1) 0/5 (G2)	0 (G1) 0 (G2)	No failures	NM	Crestal	3.8/4.3 3.8/4.8 3.8/5.5
de Almeida et al.[39]	2011	RA (unicentre)	26 (16, G1; 10, G2)	25–70 (41)	Mean 33 months (range 6–60)	NM	1–6 months	0/27 (G1) 0/15 (G2)[b]	–	–	NM	Subcrestal (36 of 42)	3.8/5.5 4.5/6.5
Pieri et al.[21]	2011	RCT (unicentre)	40 (20, G1; 20, G2)	26–67 (46)	1 year	7/7	Immediate	1/20 (G1) 0/20 (G2)	5 (G1) 0 (G2)	NM	NM	Supracrestal (0.5 mm)	Mismatch of 0.35 mm
Canullo et al.[22]	2012	RCT (multicentre)	40[a]	NM (58.2)	18 months of loading	6/14	2–3 months	0/40 (G1) 0/40 (G2)	0 (G1) 0 (G2)	No failures	0 (G1) 0 (G2)	Crestal	Mismatch of 0.5 mm
Dursun et al.[34]	2012	CCT (unicentre)	19 (NM)	25–57 (43)	6 months	6/NM	3 months	0/16 (G1) 0/16 (G2)	0 (G1) 0 (G2)	No failures	NM	NM	NM/3.75 or 3.8

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Table 1 (*Continued*)

Authors	Published	Study design	Patients (*n*)	Patients' age range (average) (years)	Follow-up visits (or range)	Antibiotics/ mouth rinse (days)	Healing period/ loading	Failed/ placed implants (*n*)	Implant failure rate (%)	*P* value (for failure rate)	Postoperative infection	Bone level of the implant platform	Abutment/ implant platform (G2; mm)
Fernandez-Formoso et al.[23]	2012	RCT (unicentre)	51 (26, G1; 25, G2)	26–69 (43)	1 year	NM	NM	NM/58 (G1) NM/56 (G2)	–	–	NM	Crestal	NM
Enkling et al.[25]	2013	RCT (unicentre)	25[a]	NM (51)	3 years	NM	4 months	0/25 (G1) 0/25 (G2)	0 (G1) 0 (G2)	No failures	NM	Crestal	3.3/4.0
Gultekin et al.[35]	2013	CCT (unicentre)	25[a]	19–59 (41.3)	15 months	3/14	3 months	0/43 (G1) 0/50 (G2)	0 (G1) 0 (G2)	No failures	NM	Crestal	Mismatch of 0.25 mm
Peñarrocha-Diago et al.[24]	2013	RCT (unicentre)	15 (7, G1; 8, G2)	44–77 (56.9)	1 year	NM	3 months	1/64 (G1) 1/56 (G2)	1.56 (G1) 1.79 (G2)	NM	NM	Crestal	NM
Telleman et al.[26]	2013	RCT (unicentre)	92 (45, G1; 47, G2)	18–70 (50)	1 year	NM	4 months	3/73 (G1) 6/76 (G2)	4.11 (G1) 7.89 (G2)	0.33	NM	Crestal	3.3/4.0 4.2/5.0
Vandeweghe et al.[40]	2013	RA (multicentre)	38[a]	20–82 (49)	Mean 26 months (range 8–44)	NM	Immediate	0/9 (G1) 0/34 (G2)	0 (G1) 0 (G2)	No failures	NM	NM	NM
Glibert et al.[36]	2014	CCT (unicentre)	48 (NM)	> 18	Mean 20 months (range 14–27)	10/"prescribed"	Immediate (n = 95) 10 weeks (n = 20)	0/45 (G1) 0/70 (G2)	0 (G1) 0 (G2)	No failures	NM	Crestal Subcrestal (2–3 mm; in the cases of fresh sockets)	4.0/5.0
Meloni et al.[27]	2014	RCT (unicentre)	18 (split-mouth)	28–70 (48)	1 year	7/14	3 months	0/18 (G1) 0/18 (G2)	0 (G1) 0 (G2)	No failures	0 (G1) 0 (G2)	NM	3.5/4.3 4.3/5.0
Rocha et al.[28]	2014	RCT (multicentre)	76 (39, G1; 37, G2)	NM (51)	2 years	According to the procedures of each centre	10 weeks	2/83 (G1) 1/80 (G2)	2.41 (G1) 1.25 (G2)	>0.05	NM	NM	3.2/3.8 3.7/4.3 4.3/5.0
Telleman et al.[29]	2014	RCT (unicentre)	17 (split-mouth)	21–67 (53.7)	1 year	NM	4 months	2/31 (G1) 2/31 (G2)	6.45 (G1) 6.45 (G2)	Equal failure rates	NM	Crestal	3.3/4.0 4.2/5.0
Wang et al.[30]	2014	RCT (unicentre)	19[a]	23–76 (55.4)	1 year	"Prescribed"/21	3 months	0/15 (G1) 0/15 (G2)	0 (G1) 0 (G2)	No failures	NM	Subcrestal (0.5 mm)	Mismatch of 0.6 mm

NM, not mentioned; NP, not performed; RCT, randomized controlled trial; CCT, controlled clinical trial; RA, retrospective analysis; G1, group platform-switched implants; G2, group platform-matched implants; HA-coated, hydroxyapatite-coated; SC, single crown; FPP, fixed partial prosthesis; FAP, full-arch prosthesis; GBR, guided bone regeneration.

[a] Some or all patients received both platform-switched and platform-matched implants.

[b] Unpublished information was obtained by personal communication with one of the authors.

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Table 2 – Detailed data of the included studies – Part 2.

Authors	Marginal bone loss (mean ± SD) (mm)	Implant surface modification (brand)	Region/prosthetic rehabilitation/ opposing dentition	Observations
Hürzeler et al.[14]	0.12 ± 0.40 (G1, *n* = 14) 0.29 ± 0.34 (G2, *n* = 8) (1 year)	Acid-etched (Implant Innovations, Palm Beach Gardens, FL, USA)	Maxilla, mandible/ SC, FPP/NM	Only in the posterior region
Canullo et al.[15]	NM	Sandblasted and acid-etched (Global, Sweden & Martina, Padua, Italy)	Maxilla/SC/NM	Only in region of teeth 15–25, all implants inserted in fresh extraction sockets, patients who smoked less than 10 cigarettes/day were also included, but the exact number was not informed
Crespi et al.[16]	0.78 ± 0.49 (G1, *n* = 30) 0.82 ± 0.40 (G2, *n* = 34), (1 year) 0.73 ± 0.52 (G1, *n* = 30) 0.78 ± 0.45 (G2, *n* = 34), (2 years)	Sandblasted and acid-etched (Ankylos Plus, Dentsply-Friadent, Mannheim, Germany, G1), sandblasted and acid-etched (Seven, Sweden & Martina, Padua, Italy, G2)	Maxilla, mandible/ SC, FPP/NM	All implants inserted in fresh extraction sockets, patients who smoked less than 10 cigarettes/day were also included, but the exact number was not informed
Kielbassa et al.[17]	0.95 ± 1.37 (G1, internal hexagon, *n* = 87) 0.64 ± 0.97 (G1, external hexagon, *n* = 69) 0.63 ± 1.18 (G2, *n* = 85) (1 year)	Oxidized (TiUnite, NobelActive, G1; NobelReplace Tapered Groovy, G2; Nobel Biocare AB, Göteborg, Sweden)	Maxilla, mandible/ SC (52.3%), FPP (35.7%), FAP (12%)/ NM	Grafting procedures in 18 implant sites, all implants inserted in healed sites (minimum of 6 months postextraction healing)
Prosper et al.[3]	0.013 ± 0.091 (G1, submerged, *n* = 120) 0.272 ± 0.367 (G2, submerged, *n* = 120) 0.101 ± 0.274 (G2, nonsubm., *n* = 120), (1 year) 0.045 ± 0.227 (G1, submerged, *n* = 120) 0.275 ± 0.467 (G2, submerged, *n* = 120) 0.193 ± 0.474 (G2, nonsubm., *n* = 120), (2 years)	Sandblasted and acid-etched (BioActive Covering SLA, Winsix Ltd., London, United Kingdom)	Maxilla, mandible/ NM/NM	No smokers, all implants inserted in healed sites (minimum of 3 months postextraction healing)
Trammell et al.[18]	0.99 ± 0.53 (G1, *n* = 13) 1.19 ± 0.58 (G2, *n* = 12), (2 years)	Acid-etched (Osseotite Certain NTXP, G1; Osseotite Certain, G2; Biomet 3i, Palm Beach Gardens, FL, USA)	NM/SC, FPP/NM	Patients who smoked less than 10 cigarettes/day were also included, but the exact number was not informed
Vigolo and Givani[31]	0.6 ± 0.2 (G1, *n* = 97), 0.9 ± 0.3 (G2, *n* = 85), (1 year) 0.6 ± 0.2 (G1, *n* = 97), 1.0 ± 0.3 (G2, *n* = 85), (2 years) 0.6 ± 0.2 (G1, *n* = 97), 1.0 ± 0.3 (G2, *n* = 85), (3 years) 0.6 ± 0.2 (G1, *n* = 97), 1.1 ± 0.3 (G2, *n* = 85), (4 years) 0.6 ± 0.2 (G1, *n* = 97), 1.1 ± 0.3 (G2, *n* = 85), (5 years)	Acid-etched (3i/ Implant Innovations, Palm Beach Gardens, FL, USA)	Maxilla, mandible/ SC/NM	Only in the molar region

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Table 2 (*Continued*)

Authors	Marginal bone loss (mean ± SD) (mm)	Implant surface modification (brand)	Region/prosthetic rehabilitation/ opposing dentition	Observations
Bilhan et al.[37]	0.43 ± 0.12 (6 months), 0.77 ± 0.15 (1 year) 0.86 ± 0.16 (2 years), 0.89 ± 0.16 (3 years) (G1, mesial, *n* = 75) 0.47 ± 0.14 (6 months), 0.82 ± 0.17 (1 year) 0.91 ± 0.18 (2 years), 0.98 ± 0.20 (3 years) (G2, mesial, *n* = 51) 0.44 ± 0.12 (6 months), 0.79 ± 0.17 (1 year) 0.87 ± 0.17 (2 years), 0.91 ± 0.17 (3 years) (G1, distal, *n* = 75) 0.48 ± 0.14 (6 months), 0.85 ± 0.18 (1 year) 0.95 ± 0.19 (2 years), 1.00 ± 0.19 (3 years) (G2, distal, *n* = 51)	Several (Astra, Astratech AB, Mölndal, Sweden, *n* = 75; ITI, Straumann AG, Waldenburg, Switzerland; *n* = 25; Zimmer, Zimmer Dental, Carlsbad, CA, USA; Biolok, Biohorizons, Birmingham, AL, USA, *n* = 14)	Mandible/ overdentures/NM	–
Canullo et al.[19]	0.74 ± 0.39 (9 months), 0.95 ± 0.35 (15 months) 0.99 ± 0.417 (21 months), 0.99 ± 0.42 (33 months) (G1, 3.8/4.3, *n* = 17) 0.64 ± 0.40 (9 months), 0.78 ± 0.35 (15 months) 0.82 ± 0.362 (21 months), 0.87 ± 0.43 (33 mo) (G1, 3.8/4.8, *n* = 13) 0.41 ± 0.28 (9 months), 0.51 ± 0.29 (15 months) 0.56 ± 0.31 (21 months), 0.64 ± 0.32 (33 months) (G1, 3.8/5.5, *n* = 14) 1.23 ± 0.67 (9 months), 1.46 ± 0.53 (15 months) 1.49 ± 0.544 (21 months), 1.48 ± 0.42 (33 monthso) (G2, *n* = 17)	Sandblasted and acid-etched (Global, Sweden & Martina, Padua, Italy)	Maxilla/FPP/NM	Only in the posterior region, 21 sinus lifts, all implants inserted in healed sites (minimum of 6 months postextraction healing), patients who smoked less than 10 cigarettes/ day were also included, but the exact number was not informed
Fickl et al.[32]	0.30 ± 0.07 (G1, *n* = 75) 0.68 ± 0.17 (G2, *n* = 14), (3 months) 0.39 ± 0.07 (G1, *n* = 75) 1.00 ± 0.22 (G2, *n* = 14), (1 year)	Acid-etched (Osseotite, Biomet 3i, Palm Beach Gardens, FL, USA)	Maxilla, mandible/ SC, FPP/NM	All implants inserted in healed sites
Linkevicius et al.[33]	1.81 ± 0.39 (G1, mesial, *n* = 6) 1.60 ± 0.46 (G2, mesial, *n* = 6) 1.70 ± 0.35 (G1, distal, *n* = 6) 1.76 ± 0.45 (G2, distal, *n* = 6) (1 year)	Acid-etched + CaP particles deposition (Prevail, 3i Biomet, Palm Beach Gardens, FL, USA, G1), HA-coated (Prodigy, BioHorizons, Birmingham, AL, USA, G2)	Maxilla, mandible/ FPP/NM	No smokers, all implants inserted in healed sites (minimum of 6 months postextraction healing)

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Table 2 (*Continued*)

Authors	Marginal bone loss (mean ± SD) (mm)	Implant surface modification (brand)	Region/prosthetic rehabilitation/ opposing dentition	Observations
Veis et al.[38]	0.75 ± 0.55 (G1, *n* = 89) 0.69 ± 0.47 (G1, supracrestal, *n* = 34) 1.13 ± 0.42 (G1, crestal, *n* = 30) 0.39 ± 0.52 (G1, subcrestal, *n* = 25) 0.88 ± 0.85 (G2, *n* = 193) 0.60 ± 0.67 (G2, supracrestal, *n* = 64) 1.23 ± 0.96 (G2, crestal, *n* = 65) 0.81 ± 0.79 (G2, subcrestal, *n* = 64) (2 years)	Acid-etched (Osseotite, Biomet 3i, Palm Beach Gardens, FL, USA)	Maxilla, mandible/ SC, FPP/NM	Implants placed at 3 different crestal levels: supracrestal, crestal, and subcrestal
Canullo et al.[20]	0.83 ± 0.44 (G1, 3.8/4.3, *n* = 6) 0.49 ± 0.22 (G1, 3.8/4.8, *n* = 5) 0.38 ± 0.12 (G1, 3.8/5.5, *n* = 6) 1.36 ± 0.39 (G2, *n* = 5) (3 years)	Sandblasted and acid-etched (Global, Sweden & Martina, Padua, Italy)	Maxilla/FPP/NM	Only in the posterior region, patients who smoked less than 10 cigarettes/day were also included, but the exact number was not informed
de Almeida et al.[39]	0.27 (G1, *n* = 27) 2.30 (G2, *n* = 15) (mean 30-G1 and 39-G2 months)	HA-coated (Frialit-2, Dentsply Friadent, Mannheim, Germany)	Maxilla, mandible/ SC/NM	All implants inserted in healed sites (minimum of 6 months postextraction healing)
Pieri et al.[21]	0.09 ± 0.1 (G1, *n* = 19) 0.24 ± 0.15 (G2, *n* = 19), (4 months) 0.2 ± 0.17 (G1, *n* = 18) 0.51 ± 0.24 (G2, *n* = 19), (1 year)	Calcium- and phosphorus-enriched titanium oxide surface (Samo Smiler Implants, Biospark, Bologna, Italy)	Maxilla/SC/natural dentition or fixed restoration	Only premolars, all implants inserted in fresh extraction sockets, 3 smokers, grafting procedures in all implants
Canullo et al.[22]	0.5 ± 0.1 (G1, *n* = 40) 1.6 ± 0.3 (G2, *n* = 40) (18 months)	Sandblasted and acid-etched or anodized (Amplified, P-I Brånemark Philosophy, Bauru, Brazil, G1), sandblasted and acid-etched or anodized (EH, P-I Brånemark Philosophy, Bauru, Brazil, G2)	Maxilla/FPP/NM	Only in the posterior region, 58 implants inserted after sinus lifting, patients who smoked less than 10 cigarettes/day were also included, but the exact number was not informed
Dursun et al.[34]	0.11 ± 0.09 (G1, *n* = 16) 0.19 ± 0.24 (G2, *n* = 16), (1 month) 0.34 ± 0.24 (G1, *n* = 16) 0.31 ± 0.23 (G2, *n* = 16), (3 months) 0.72 ± 0.53 (G1, *n* = 16) 0.56 ± 0.35 (G2, *n* = 16), (6 months)	Sandblasted and acid-etched (Revois, Curasan AG, Germany; G1), sandblasted and acid-etched (Tapered Screw Vent, Zimmer Dental, Carlsbad, CA, USA; G2)	Mandible/''fixed prosthesis''/NM	Only in premolar/ molar regions, single-stage protocol, no smokers, no bruxers, all implants inserted in healed sites (sockets left to heal between 6 months and 1 year)
Fernandez-Formoso et al.[23]	−0.01 ± 0.50 (G1, *n* = 58) 0.42 ± 0.11 (G2, *n* = 56) (1 year)	Sandblasted and acid-etched (SLA; Bone Level Type, G1; Standard Plus Type, G2; Straumann, Waldenburg, Switzerland)	Maxilla, mandible/ SC, FPP/NM	Only in the posterior region, all implants inserted in healed sites (minimum of 3 months postextraction healing), no smokers

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Table 2 (*Continued*)

Authors	Marginal bone loss (mean ± SD) (mm)	Implant surface modification (brand)	Region/prosthetic rehabilitation/ opposing dentition	Observations
Enkling et al.[25]	0.33 ± 0.52 (G1, *n* = 25), 0.38 ± 0.43 (G2, *n* = 25), (3 months) 0.44 ± 0.42 (G1, *n* = 25), 0.46 ± 0.55 (G2, *n* = 25), (4 months) 0.53 ± 0.35 (G1, *n* = 25), 0.58 ± 0.55 (G2, *n* = 25), (12 months) 0.56 ± 0.35 (G1, *n* = 25), 0.63 ± 0.57 (G2, *n* = 25), (25 months) 0.69 ± 0.43 (G1, *n* = 25), 0.74 ± 0.57 (G2, *n* = 25), (38 months)	Sandblasted and acid-etched (SICace, SIC-Invent AG, Basel, Switzerland)	Mandible/SC/NM	Only in the posterior region, all implants inserted in healed sites (minimum of 6 months postextraction healing)
Gultekin et al.[35]	0.22 ± 0.11 (G1, *n* = 43) 0.24 ± 0.14 (G2, *n* = 50), (3 months) 0.35 ± 0.13 (G1, *n* = 43) 0.83 ± 0.16 (G2, *n* = 50), (1 year)	Oxidized (TiUnite, Nobel Biocare AB, Göteborg, Sweden)	Maxilla, mandible/ NM/NM	No smokers, no bruxers, all implants inserted in healed sites (minimum of 4 months postextraction healing)
Peñarrocha-Diago et al.[24]	0.07 ± 0.13 (G1, *n* = 64) 0.27 ± 0.43 (G2, *n* = 56), (6 months) 0.12 ± 0.17 (G1, *n* = 64) 0.38 ± 0.51 (G2, *n* = 56), (1 year)	Resorbable blast media (Inhex, Mozo-Grau, Valladolid, Spain, G1), turned (Osseous, Mozo-Grau, Valladolid, Spain, G2)	Maxilla, mandible/ FPP, overdenture/ NM	Only completely edentulous patients, 3 smokers
Telleman et al.[26]	0.51 ± 0.56 (G1, *n* = 73) 0.76 ± 0.60 (G2, *n* = 76), (1 month) 0.50 ± 0.53 (G1, *n* = 73) 0.74 ± 0.61 (G2, *n* = 76), (1 year)	Acid-etched + CaP particles deposition (NanoTite Certain Prevail, Biomet 3i, Palm Beach Gardens, FL, USA; G1), acid-etched + CaP particles deposition (NanoTite XP Certain, Biomet 3i, Palm Beach Gardens, FL, USA; G2)	Maxilla, mandible/ SC, FPP/NM	Only in the posterior region, short implants only (8.5 mm), no smokers, all implants inserted in healed sites (minimum of 3–4 months postextraction healing), GBR in some cases
Vandeweghe et al.[40]	0.78 ± 0.39 (G1, *n* = 9) 1.06 ± 0.24 (G2, *n* = 34) (mean 26 months)	Sandblasted (Southern Implants, Irene, South Africa)	Maxilla, mandible/ SC/NM	23 implants placed in fresh extraction sockets, 5 smokers
Glibert et al.[36]	0.63 ± 0.18 (G1, *n* = 45) 1.02 ± 0.14 (G2, *n* = 70) (1 year)	Acid-etched (Osseotite 2 Certain, Biomet 3i, Palm Beach, FL, USA)	Maxilla, mandible/ SC, FPP/NM	8 implants in fresh extraction sockets using a flapless approach. Patients who were diabetic and who smoke were also included, but the exact number was not informed
Meloni et al.[27]	0.23 ± 0.13 (G1, *n* = 18) 0.26 ± 0.15 (G2, *n* = 18), 6 months 0.50 ± 0.27 (G1, *n* = 18) 0.56 ± 0.22 (G2, *n* = 18), 1 year	Oxidized (TiUnite, Nobel Replace Tapered Groovy, Nobel Biocare, Goteborg, Sweden)	Maxilla, mandible/ SC/NM	Only in patients with bilaterally missing single molars. Patients who smoked less than 10 cigarettes/day were also included, but the exact number was not informed

Table 2 (*Continued*)

Authors	Marginal bone loss (mean ± SD) (mm)	Implant surface modification (brand)	Region/prosthetic rehabilitation/ opposing dentition	Observations
Rocha et al.[28]	0.53 ± 0.45 (G1, *n* = 76) 0.63 ± 0.70 (G2, *n* = 70), (10 weeks) 0.43 ± 0.42 (G1, *n* = 76) 0.72 ± 0.60 (G2, *n* = 68), (12 months) 0.27 ± 0.44 (G1, *n* = 69) 0.79 ± 0.68 (G2, *n* = 64), (24 months)	Sandblasted and acid-etched (Screw-line Promote, Camlog Biotechnologies AG, Basel, Switzerland)	Mandible/SC/"fixed dentition"	Only in the posterior region, 9 smokers
Telleman et al.[29]	0.44 ± 0.57 (G1, *n* = 31) 0.82 ± 0.59 (G2, *n* = 31), (1 month) 0.53 ± 0.54 (G1, *n* = 29) 0.85 ± 0.65 (G2, *n* = 29), (1 year)	Acid-etched + CaP particles deposition (Certain Prevail, Biomet 3i, Palm Beach Gardens, FL, USA; G1), acid-etched + CaP particles deposition (XP Certain, Biomet 3i, Palm Beach Gardens, FL, USA; G2)	Maxilla, mandible/ SC, FPP/NM	Only in the posterior region, short implants only (8.5 mm), no smokers, all implants inserted in healed sites (minimum of 3–4 months postextraction healing), GBR in some cases
Wang et al.[30]	0.08 ± 0.19 (G1, *n* = 8) 0.05 ± 0.07 (G2, *n* = 11), (3 months) 0.10 ± 0.17 (G1, *n* = 8) 0.17 ± 0.19 (G2, *n* = 11), (6 months) 0.04 ± 0.08 (G1, *n* = 8) 0.19 ± 0.16 (G2, *n* = 11), (1 year)	Sandblasted and acid-etched (Superline, Dentium USA, Cypress, CA, USA)	Maxilla, mandible/ SC/natural dentition	Only in the posterior region, no smokers, all implants inserted in healed sites

y = 0.099 + 0.015*x*; Fig. 3). According to this statistical model, an increase of each year in follow-up time increases the MD in 0.180 mm (12 × 0.015). Moreover, the mismatch was also considered as a covariate. It was observed that the bigger the mismatch between the implant platform and the abutment, the bigger the mean difference of the MBL between the platform-switched and the platform-matched implants, the MD being statistically significant ($P = 0.001$; $y = -0.041 + 0.907x$; Fig. 4). According to this statistical model, an increase of every 0.1 mm in the mismatch increases the MD in 0.0907 mm (0.907/10).

3.6. *Publication bias*

The funnel plot did not show a clear asymmetry when the studies reporting the outcome 'MBL' were analyzed (Fig. 5), indicating possible absence of publication bias.

4. Discussion

The present study cannot suggest that the insertion of platform-switched implants affects the implant failure rates or postoperative infection. As some of the included studies are limited by a small cohort size and only six studies[17,21,24,26,28,30] reported occurrences of implant failure and only other six studies[15,16,19,22,27,37] provided information about postoperative infection, with no occurrences, it is difficult to properly estimate this influence.

This study observed that platform-switched implants, in comparison to the platform-matched implants, results in significantly less MBL. The magnitude of the marginal bone level alterations observed varied among the studies, which may be due to different observation periods. Thus, the analysis was classified in subgroups of different follow-up periods, showing that there was an increase of the MD of MBL between the approaches with the increase in the follow-up periods, being statistically significant. It seems that there is indeed a higher short-term MBL in platform-matched implants in comparison with the platform-switched implants, but there is a slightly evidence that the curve levels out with time (change of the MD with time: −0.13, −0.11, −0.24, −0.46, −0.60; see Fig. 2). The possibility cannot be ignored, but it is not known whether the loss of marginal bone is a long term process. The problem is that there are only few studies with a long follow-up. Moreover, it is debatable whether such mean difference may have clinical significance.

Several hypotheses trying to explain this phenomenon have been raised in the literature. Some studies have shown that bone resorption around the implant neck does not begin until the implant is uncovered and exposed to the oral cavity, which invariably leads to bacterial contamination of the gap between implant and superstructure.[5,41,42] The bacterial reservoir in a microgap may continuously invade the bone, resulting in peri-implant inflammation and bone loss.[43] This phenomenon, known as bacterial microleakage, may influence peri-implant health,[44] at least in the short term. The

Table 3 – Quality assessment of the studies by Newcastle-Ottawa scale (NOS).

Study	Published	Selection				Comparability		Outcome			Total (9/9)
		Representativeness of the exposed cohort	Selection of external control	Ascertainment of exposure	Outcome of interest not present at start	Comparability of cohorts		Assessment of outcome	Follow-up long enough[a]	Adequacy of follow-up	
						Main factor	Additional factor				
Hürzeler et al.[14]	2007	0	★	★	★	★	0	★	0	★	6/9
Canullo et al.[15]	2009	0	★	★	★	★	★	★	0	★	7/9
Crespi et al.[16]	2009	0	★	★	★	★	★	★	0	★	7/9
Kielbassa et al.[17]	2009	0	★	★	★	★	★	★	0	★	7/9
Prosper et al.[3]	2009	0	★	★	★	★	★	★	0	★	7/9
Trammell et al.[18]	2009	★	★	★	★	★	0	★	0	0	6/9
Vigolo and Givani[31]	2009	0	★	★	★	★	0	★	★	0	6/9
Bilhan et al.[37]	2010	0	★	★	★	★	0	★	0	0	5/9
Canullo et al.[19]	2010	0	★	★	★	★	★	★	0	★	7/9
Fickl et al.[32]	2010	0	★	★	★	★	0	★	0	★	6/9
Linkevicius et al.[33]	2010	0	★	★	★	★	0	★	0	★	6/9
Veis et al.[38]	2010	★	★	★	★	★	★	★	0	0	7/9
Canullo et al.[20]	2011	0	★	★	★	★	★	★	0	★	7/9
de Almeida et al.[39]	2011	★	★	★	★	★	0	★	0	0	6/9
Pieri et al.[21]	2011	0	★	★	★	★	★	★	0	★	7/9
Canullo et al.[22]	2012	0	★	★	★	★	★	★	0	★	7/9
Dursun et al.[34]	2012	0	★	★	★	★	★	★	0	★	7/9
Fernandez-Formoso et al.[23]	2012	0	★	★	★	★	0	★	0	★	6/9
Enkling et al.[25]	2013	0	★	★	★	★	0	★	0	★	6/9
Gultekin et al.[35]	2013	0	★	★	★	★	0	★	0	0	5/9
Peñarrocha-Diago et al.[24]	2013	0	★	★	★	★	★	★	0	★	7/9
Telleman et al.[26]	2013	0	★	★	★	★	★	★	0	★	7/9
Vandeweghe et al.[40]	2013	0	★	★	★	★	★	★	0	0	6/9
Glibert et al.[36]	2014	★	★	★	★	★	★	★	0	0	7/9
Meloni et al.[27]	2014	0	★	★	★	★	0	★	0	★	6/9
Rocha et al.[28]	2014	0	★	★	★	★	★	★	0	★	7/9
Telleman et al.[29]	2014	0	★	★	★	★	★	★	0	★	7/9
Wang et al.[30]	2014	0	★	★	★	★	★	★	0	★	7/9

[a] Five years of follow-up was chosen to be enough for the outcome 'implant failure' to occur.

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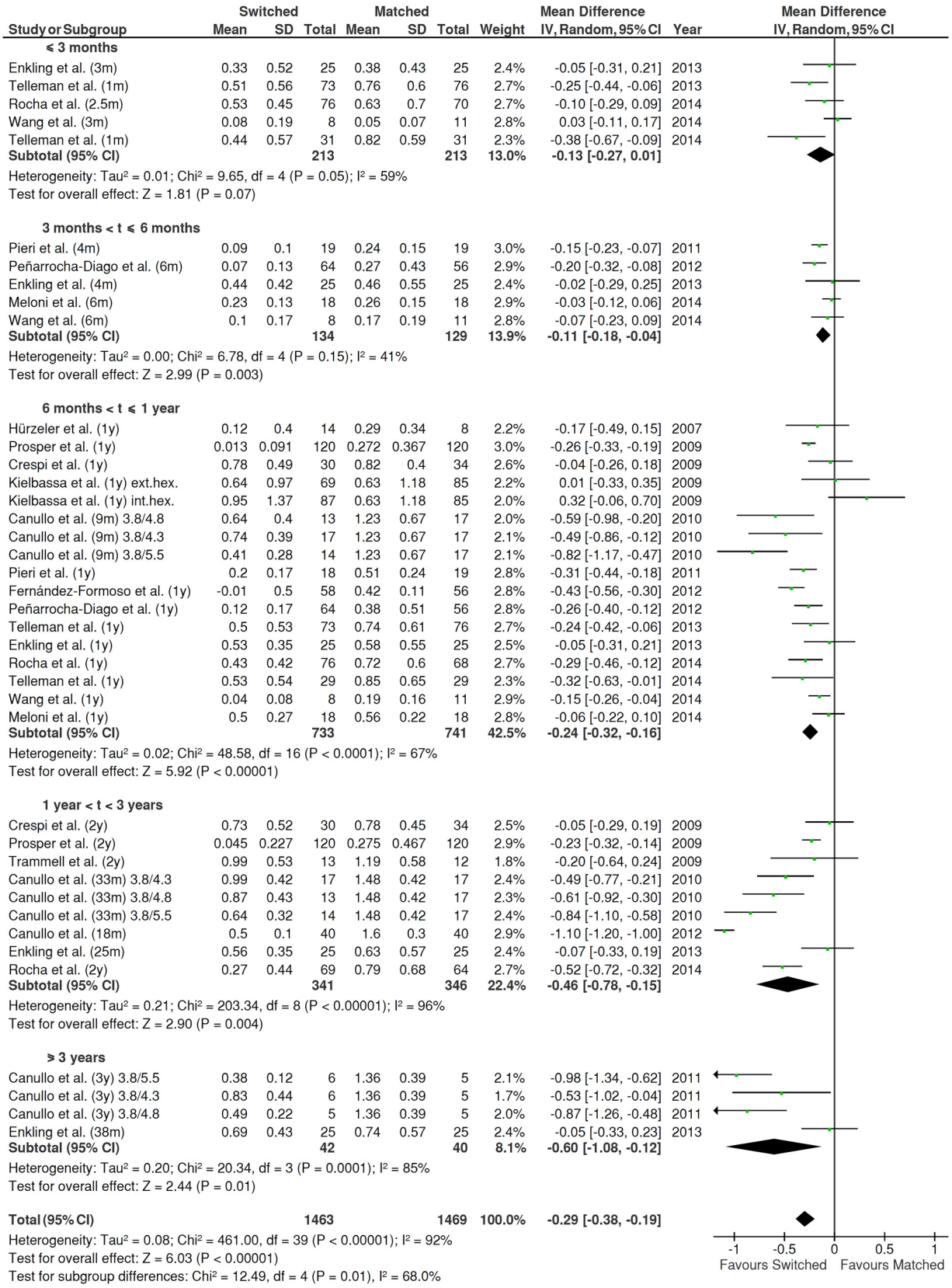

Fig. 2 – Forest plot for the event 'marginal bone loss'.

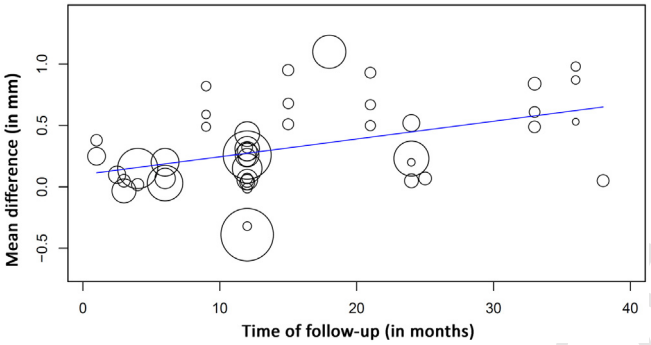

Fig. 3 – Scatter plot for the meta-regression with the association between the mean differences (in millimetres) of the marginal bone loss between the two procedures (platform-switched vs. platform-matched) and the follow-up time (in months).

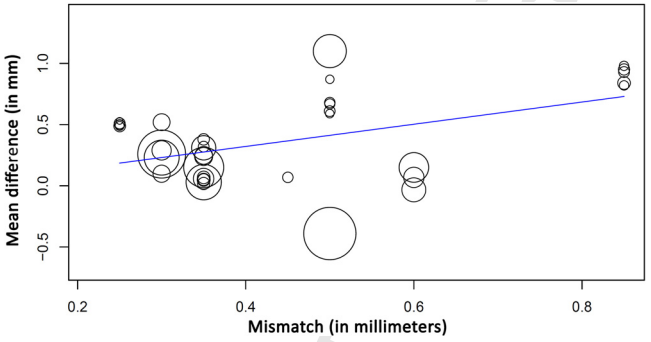

Fig. 4 – Scatter plot for the meta-regression with the association between the mean differences (in millimetres) of the marginal bone loss between the two procedures (platform-switched vs. platform-matched) and the mismatch (in millimetres).

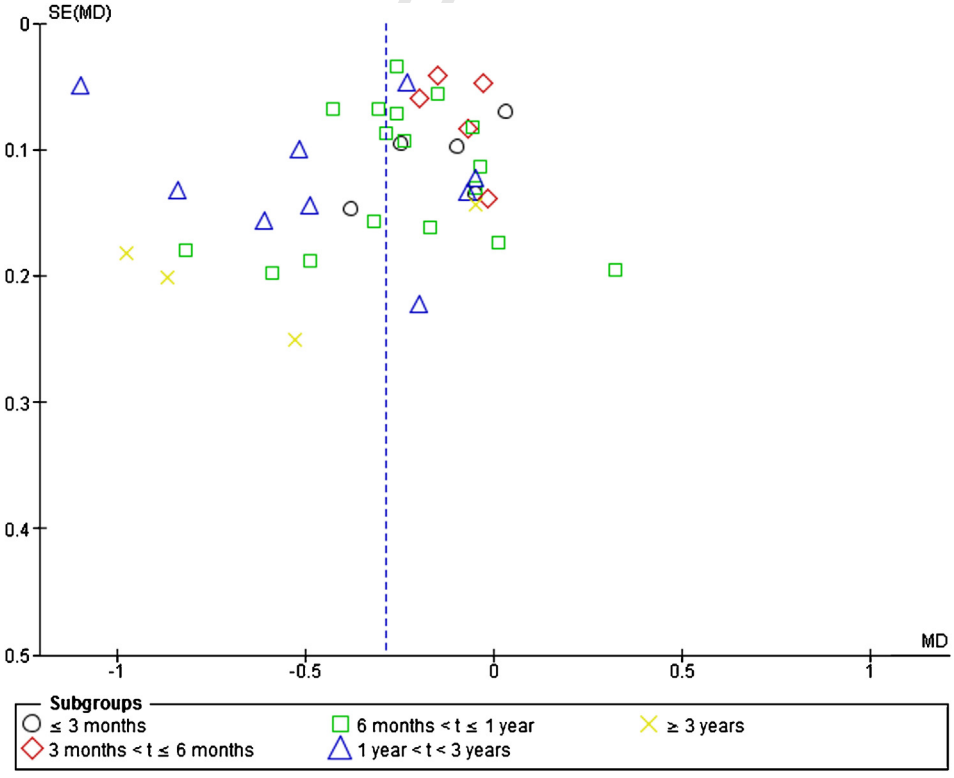

Fig. 5 – Funnel plot for the studies reporting the outcome event 'marginal bone loss'.

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platform-switching concept requires the implant–abutment interface be placed away from the implant shoulder and closer towards the axis to increase the distance of the microgap from the bone,[4] and thereby decrease its bone resorptive effect[5] caused by the bacterial microleakage, findings supported by animal[45,46] and human histological studies.[47,48] Additional bone resorption seems to be correlated to micro-movements at the abutment–implant interface.[49] The platform-switch approach may keep away the micromotion between the implant and abutment from the bone.

Moreover, it was observed that the bigger the mismatch between the implant platform and the abutment, the bigger the MD of the MBL between the platform-switched and the platform-matched implants, being statistically significant. This means that increasing the distance between the implant–abutment interface and adjacent bone may increase the anti-bone-resorptive effect of the platform-switching concept. It has been speculated that the findings of reduced bone remodelling accompanying a larger implant–abutment difference may be due to an increased implant diameter rather than to the platform,[25] because a bigger mismatch is often caused by the use of a wider diameter.[29]

It is important to stress that the associations found in these meta-regressions (with the covariates follow-up time and the platform mismatch) should be considered hypothesis generating only and cannot be regarded as proof of causality.[50]

The large variation in results between studies may be due to the fact that the studies differed regarding the use of implant–abutment connection type, i.e. different platform designs, and the surface texture at the implant neck/collar. One example is the difference between the horizontal platforms of the Brånemark (Nobel Biocare AB, Göteborg, Sweden) and Osseotite (Biomet 3i, Palm Beach Gardens, FL, USA) implants when compared to the inclined platform of the Straumann (Straumann AG, Waldenburg, Switzerland) and Astra (Astratech AB, Mölndal, Sweden) implants. It is unknown to which magnitude these differences in platform design may affect the results. Concerning the collar implant design, a dog model study[51] observed that choosing a completely SLA-surfaced non-submerged implant can reduce the amount of peri-implant crestal bone loss and reduce the distance from the microgap between implant/abutment to the first bone–implant contact around unloaded implants compared to implants with a machined collar. On the other hand, a recent human clinical trial[52] evaluated two similar implant types differing only in the surface texture of the neck and showed no significant influence on marginal bone level changes. Unfortunately, the data were insufficient to allow for statistical assessment of implant design characteristics.

All these results also depend on the location of the microgap in relation to the level of the crestal bone. Hermann et al.[53] observed in an animal model that if the microgap was moved coronally away from the alveolar crest, less bone loss would occur, whereas if the microgap moved apical to the alveolar crest, greater amounts of bone resorption were seen. In their clinical human study, Veis et al.[38] noted that the beneficial effect of the platform-switched concept was evident only in subcrestal implants, not in crestal or supracrestal ones. As the position of the implant platform varied from study to study, and this information was not provided by every included study, it may be difficult to unequivocally interpret the available evidence.

The studies here included made use of implants with different brands and surface treatments. Titanium with different surface modifications shows a wide range of chemical, physical properties, and surface topographies or morphologies, depending on how they are prepared and handled,[54–56] and it is not clear whether, in general, one surface modification is better than another.[57] The texture of the implant's surface may play a major role in marginal bone resorption.[58] It has been shown, for example, that implants with a roughened surface that extends closer to the abutment-platform junction tend to have less alveolar bone loss.[59]

The results of the present study have to be interpreted with caution because of its limitations. First of all, all confounding factors may have affected the long-term outcomes and not just the fact that implants were rehabilitated with a switched platform abutment or a matching-diameter abutment, and the impact of these variables on the implant survival rate, postoperative infection and MBL[60–65] is difficult to estimate if these factors are not identified separately between the two different procedures in order to perform a meta-regression analysis. Most of the studies, if not all, did not disclose how many implant were inserted and survived/lost in several different conditions. The use of grafting in some studies is a confounding risk factor, as well as the insertion of some or all implants in fresh extraction sockets, the insertion of implants in different locations, different healing periods, different prosthetic configurations, type of opposing dentition, different implant angulation ranges, splinting of the implants, and the presence of smokers. The real fact is that individual patients sometimes present with more than one risk factor, and groups of patients are typically heterogeneous with respect to risk factors and susceptibilities so the specific effect of an individual risk factor could be isolated neither for individual studies nor for the present review. This is understandable and expected because study populations are typically representative of normal populations with various risk factors.[66] To precisely assess the effect of a risk factor on implant outcomes, it would be ideal to eliminate all other risk factors from the study population. Not only does the coexistence of multiple risk factors within a study population create an inability to assess the specific effect of one individual risk factor, but there is a possibility that certain risk factors together may be more detrimental than the individual risk factors alone.[66] The lack of control of the confounding factors limited the potential to draw robust conclusions. Second, much of the research in the field is limited by small cohort size and short follow-up periods. Third, some of the included studies are characterized by a low level of specificity, where the assessment of the platform-switching as a complicating factor for dental implants was not the main focus of the investigation.

5. Conclusions

The results of the present study suggest that there is a significantly less MBL at implants with platform-switching

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than on implants with platform-matching. Moreover, it is also suggested that there is an increase of the MD of MBL between the approaches (platform-switched vs. platform-matched) with the increase of the follow-up time and with the increase of the mismatch between the implant platform and the abutment. Due to lack of satisfactory information, meta-analyses for the outcomes 'implant failure' and 'postoperative infection' were not performed. The results of the present review should be interpreted with caution due to the presence of uncontrolled confounding factors in the included studies, most of them with short follow-up periods.

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