



**Review Article**

ISSN: 2581-3218  
IJDR 2019; 4(1): 20-29  
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## Does the platform switching implant affect the crestal bone level? A systematic review and meta-analysis

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### Abstract

**Objectives:** To assess the effects of platform switching in patients restored with implant supported fixed restorations on implant failure and patient satisfaction. **Materials and methods:** We searched the Cochrane Oral Health Group Trial register (04 February 2017), Cochrane Central Register of Controlled Trials (The Cochrane Library 2017, Issue 02), MEDLINE (January 1966 to 04 February 2017) and the WHO International Clinical Trial Registry Platform (04 February 2017). We hand searched citation lists of relevant publications. We did not apply any language or date restrictions. Randomised controlled trials (RCTs) comparing the effectiveness of platform switching versus platform matching in patients restored with implant supported fixed restorations were included. Two reviewers independently assessed trials for inclusion and risk of bias, extracted data and checked for accuracy. We have expressed results as risk ratio (RR) or mean differences (MD), together with their 95% confidence intervals (CI). The primary outcome measures were implant failure and patient satisfaction. **Results:** We included 12 studies (513 participants). There was no difference between platform switching and matching after 1-3 years of follow up in implant failures (RR 0.32, 95% CI 0.01 to 7.70; studies = 7) or patient satisfaction (MD 0.13, 95% CI -0.29 to 0.55; participants = 24; studies = 1). Regarding marginal bone loss, when we pooled down the data obtained from six trials, we identified substantial heterogeneity (I<sup>2</sup> = 81%) with inconsistency in the direction of effect, which was unexplained by clinical or methodological differences between the studies, and accordingly we did not perform meta-analysis for this outcome. **Conclusions:** In patients restored with implant supported fixed restorations, there is insufficient evidence to support platform switching or platform matching implant-abutment connection design to improve implant survival and patient satisfaction.

**Keywords:** Randomized controlled trial, Dental Implant-Abutment Design, Dental Implant-Abutment Connection, Platform matching and Platform Switching.

### INTRODUCTION

During the first year following the restoration of the dental implants, peri-implant crestal bone usually undergoes remodeling and resorption <sup>(1)</sup>. This resorption could range from minor bone loss that have insignificant effect on implant survival, to several millimeters compromising the implant function <sup>(2)</sup>. Accordingly, the peri-implant bone level after final loading has been considered one of the success criteria for evaluating dental implant therapy, and bone loss of up to approximately 2 mm during the first year of implant loading is acceptable and the implant is considered successful <sup>(2,3,4)</sup>. Oh <sup>(5)</sup> attributed early crestal bone loss to several factors, including the micro-gap between the implant and the abutment, the implant crest module, occlusal overload, and the biologic width around the dental implant. Among the methods proposed to minimize peri-implant bone loss, was the use of a smaller diameter abutment to restore a wider implant was suggested, what is known as the platform switching concept <sup>(6,7)</sup>. This was introduced in early 1990s, when wide diameter implants were first produced, and restored with standard diameter abutments. <sup>(8)</sup>

The exact mechanism by which platform switching reduces bone loss is still unknown, and there are only few reports on the extent of bone loss prevention by this technique. Lazzara <sup>(8)</sup> stated that the inward positioning of the implant/abutment junction distances the junction away from the adjacent crestal bone and increases the surface area to which the soft tissue can attach and establish biological width. This subsequently reduces the inflammatory cell infiltrate and associated bone resorption, and the resultant biological width leads to superior esthetic outcome <sup>(9,10)</sup>.

There is no agreement on whether the design of implant abutment connection improves implant survival

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on long term. A systematic review is therefore needed to determine if platform switching affects implant failure and patient satisfaction, and to identify the ideal implant abutment junction design to be used when restoring implants with fixed prosthesis.

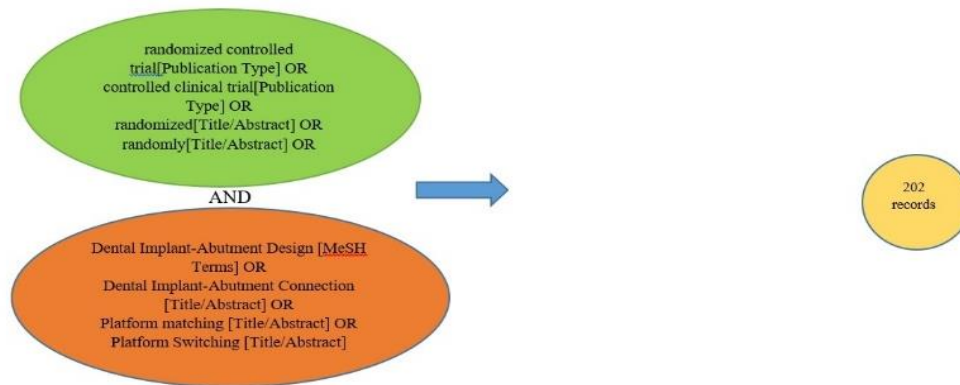
## Objectives

To assess the effects of platform switching in patients restored with implant supported fixed restorations on implant failure and patient satisfaction.

## MATERIAL AND METHODS

### Protocol and registration

This review was registered at the International Prospective Register of Systematic Reviews (<https://www.crd.york.ac.uk/PROSPERO>, registration number (CRD42016041763)). Moreover, it was conducted in agreement with the recommendations of the Cochrane Collaboration



**Figure 1:** Search strategy. The language of the search strategy was adapted to each of the searched databases regarding field tags and combination of terms

### Study inclusion and exclusion criteria

The selection process was performed by two masked reviewers (AS and HH). The studies were analyzed according to inclusion criteria:

1. Studies were limited to randomized controlled clinical trials of at least more than 6 months of duration.
2. The population was limited to subjects with single tooth implant restorations or fixed partial dentures
3. The intervention of interest was implants restored with platform matched implant-abutment connection versus implants restored with platform switched implant-abutment connection.
4. Only papers in the English language were included.

Only studies that met all inclusion criteria were analyzed according to the exclusion criteria: Trials presented only as abstracts where information on risk of bias and primary or secondary outcomes cannot be obtained and Cross-over trials or quasi-RCTs.

### Outcome variables

#### Primary outcomes

- Implant failure (defined as non-functioning implant or total implant loss)
- Patient satisfaction assessed using VAS

#### Secondary outcomes

- Marginal bone loss.

and the principles of the PRISMA (Preferred Reporting Items for Systemic Reviews and Meta-Analyses) statement. <sup>(11)</sup>

### Search strategy

We searched the Cochrane Oral Health Group Trial register (04 February 2017).

The Cochrane Oral Health Group's Trials Register contains trials identified from: Monthly searches of the Cochrane Central Register of Controlled Trials (CENTRAL); Weekly searches of MEDLINE; Weekly searches of Embase; Hand searches of journals and the proceedings of major conferences.

In addition, we searched CENTRAL (*The Cochrane Library*, 2017, Issue 02), MEDLINE (January 1966 to 04 February 2017) and the WHO International Clinical Trial Registry Platform (04 February 2017) using the search strategies detailed in figure (1).

Time frame: All the outcomes assessed at the following time intervals, starting from time of prosthesis insertion and not implant placement ranged between (1-3), (3-5) and (5-10) years.

### Data extraction

We designed a form to extract data. For eligible studies, two review authors extracted the data using the agreed form. There were no discrepancies. We entered data into Review Manager software Rev. Man. <sup>(12)</sup> and checked for accuracy. When information regarding any of the above was unclear, we contacted the authors of the original reports to provide further details.

### Quality assessment

Two review authors (AS and HH) independently assessed risk of bias for each study using the criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions Higgins <sup>(13)</sup>. There were no disagreements on the assessment of risk of bias in the included studies. The following seven criteria were used; Random sequence generation, Allocation concealment (selection bias), Blinding of participants and personnel, (performance bias), Blinding of outcome assessment (detection bias), defined inclusion/exclusion criteria, Incomplete outcome data (attrition bias) and Selective reporting (reporting bias).

The judgments about whether studies at "Low risk," "High risk," or "Unclear risk" of bias were made according to the criteria given in the Handbook Higgin <sup>(13)</sup>. With reference to (1) to (6) above, the likely magnitude and direction of the bias and whether it had an impact on the findings were assessed. The impact of the level of bias was explored through undertaking Sensitivity analysis.

## Measures of treatment effect

The statistical analysis was carried out using the Review Manager software RevMan<sup>(12)</sup>.

For dichotomous data, the results were presented as summary risk ratio with 95% CI. For continuous data, we used the mean difference with 95% CI. The statistical unit was the patient and not the implants in all the outcomes except 'implant failure', where we considered the number of implants in each group.

In trials that compared more than two intervention groups, we combined all the groups with mismatch between the implant and the abutment into one single "platform switched" group. We did not identify any cluster-randomized trials for inclusion in this review. However, if we identify any cluster-randomized trials in future updates, we will include them in the analyses along with individually randomized trials. We will adjust their sample sizes using the methods described in the *Handbook*, using an estimate of the intracluster correlation co-efficient (ICC) derived from the trial (if possible), from a similar trial or from a study of a similar population. If we use ICCs from other sources, we will report this and conduct sensitivity analyses to investigate the effect of variation in the ICC. If we identify both cluster-randomized trials and individually-randomized trials, we plan to synthesize the relevant information. We will consider it reasonable to combine the results from both if there is little heterogeneity between the study designs and the interaction between the effect of intervention and the choice of randomization unit is considered to be unlikely. We will also acknowledge heterogeneity in the randomization unit and perform a subgroup analysis to investigate the effects of the randomization unit.

## Dealing with missing data

For included studies, we noted levels of attrition. We contacted the authors for missing data. For all outcomes, we carried out analyses, as far as possible, on an intention-to-treat basis, i.e. we included all participants randomised to each group in the analyses, and all participants analysed in the group to which they were allocated, regardless of whether or not they received the allocated intervention. The denominator for each outcome in each trial was calculated as the number randomised minus any participants whose outcomes are known to be missing.

## Assessment of heterogeneity

We have assessed statistical heterogeneity in each meta-analysis using the  $T^2$ ,  $I^2$  and  $Chi^2$  statistics. We regarded heterogeneity as substantial if  $I^2$  was greater than 30% and either  $T^2$  was greater than zero, or there was a low P value (less than 0.10) in the  $Chi^2$  test for heterogeneity.

## Data synthesis

We have used fixed-effect meta-analysis for combining data where it is reasonable to assume that studies were estimating the same underlying treatment effect: i.e. where trials were examining the same intervention, and we judged the trials' populations and methods sufficiently similar. If there was clinical heterogeneity sufficient to expect that the underlying treatment effects differed between trials, or if we detected substantial statistical heterogeneity, we explored this by sensitivity analysis followed by random-effects if required.

We did not conduct the planned subgroup analyses by the type of loading, location of prosthesis, arch, and type of fixed prosthesis due to insufficiency of the data.

In future updates of this review, if there are 10 or more studies in the meta-analysis we will investigate reporting biases (such as publication bias) using funnel plots. We will assess funnel plot asymmetry visually. If

asymmetry is suggested by a visual assessment, we will perform exploratory analyses to investigate it.

## RESULTS

We identified 19 potentially eligible studies (25 reports)<sup>(14-32)</sup>. The detailed search results are depicted in PRISMA flow diagram (Figure 2).

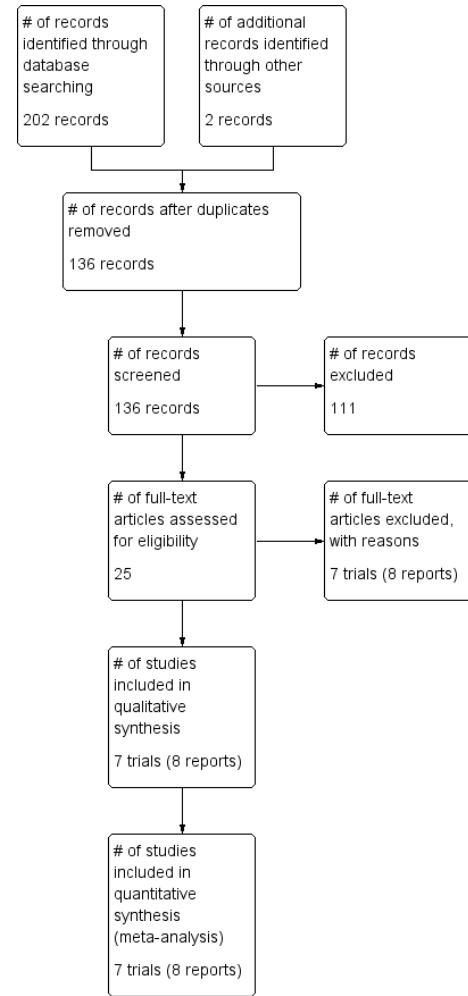


Figure 2: PRISMA flow diagram

We have provided descriptions the characteristics of included studies table (1) and reasons of excluded studies as shown in table (2).

## Included studies

The details of the included studies are shown in Table 1Twelve studies (19 reports) met the inclusion criteria for this review.

## Risk of bias in included studies

We have provided detailed descriptions of the risk of bias in the included studies see Figure 3 and Figure 4 for a summary of 'Risk of bias' assessments.

In two studies<sup>(19,25)</sup> no information was provided regarding generating the random sequence, while in the rest of the included trials adequate methods of randomization were described<sup>(14-18, 20-24)</sup>. Regarding allocation concealment, it was unclear in two studies how the random sequence was concealed<sup>(18,19)</sup>, while all the remaining trials provided adequate description of their concealment method.<sup>(14-17,20-25)</sup>.

In all the included studies neither the participants nor the caregivers were blinded. Due to the nature of the intervention, blinding is not feasible and we considered the risk of performance bias to be low.

Considering detection bias, we assessed blinding separately for different classes of outcomes. We judged the risk of detection bias to be low in objective outcomes, and high in patient reported outcomes since lack of

blinding can potentially introduce bias for this class of outcomes through multiple pathways (different expectations from the two groups and biased assessment of the effect) Higgins<sup>(13)</sup>.

Study	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias): Patient reported outcomes	Blinding of outcome assessment (detection bias): Objective outcomes	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Canillo 2012	+	+	+	+	+	+	+	+
De Angelis 2014	+	+	+	+	+	+	+	+
Enkling 2013	+	+	+	+	+	+	+	+
Fernández-Fornoso 2012	+	+	+	+	+	+	+	+
Gutmacher 2015	+	+	+	+	+	+	+	+
Hsu 2016	?	?	+	+	+	+	+	+
Meloni 2014	+	+	+	+	+	+	+	+
Pozzi 2014	+	+	+	+	+	+	+	+
Prosper 2009	+	+	+	+	+	+	+	+
Rocha 2016	+	+	+	+	+	+	+	+
Telleman 2013	+	+	+	+	+	+	+	+
Telleman 2014	+	+	+	+	+	+	+	+

Figure 3: Risk of bias summary: review authors' judgments about each risk of bias item for each included study

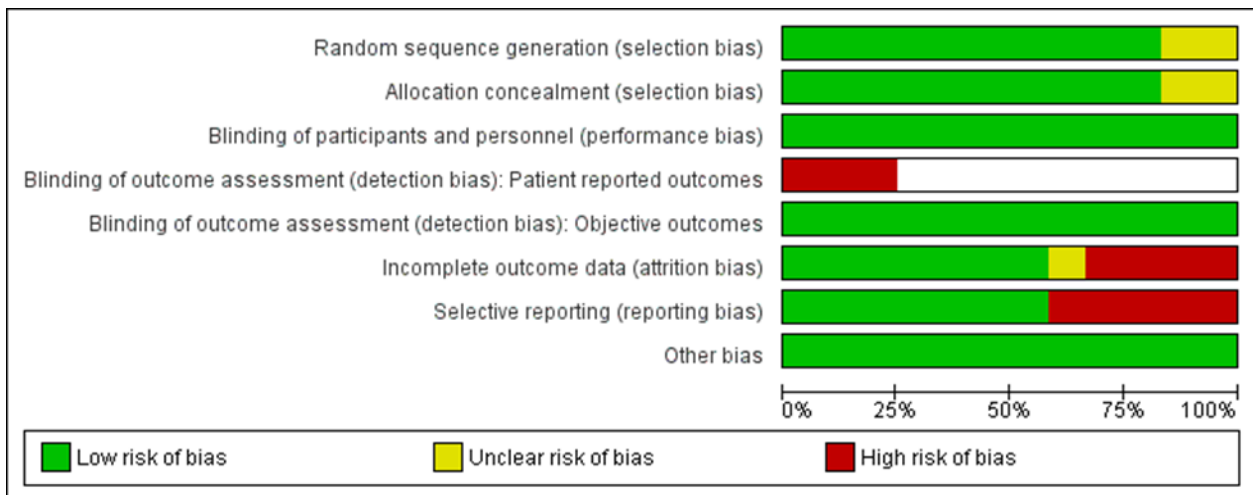


Figure 4: Risk of bias graph: review authors' judgments about each risk of bias item presented as percentages across all included studies

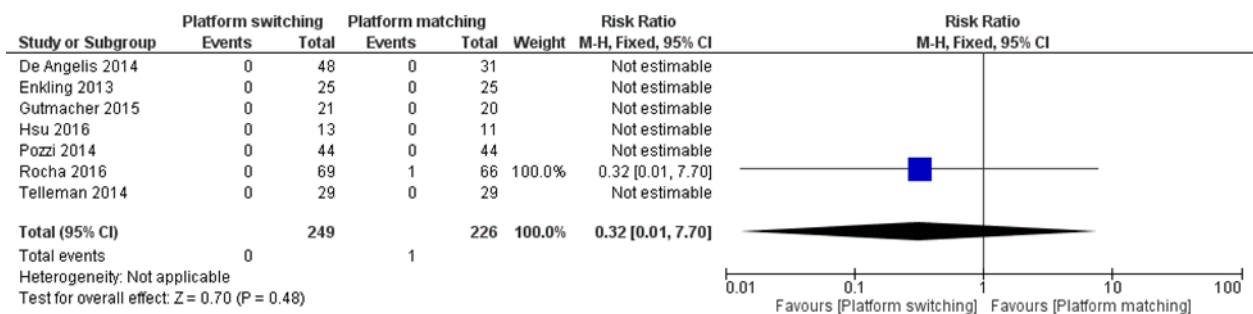


Figure 5: Analysis 1.1. Implant failure

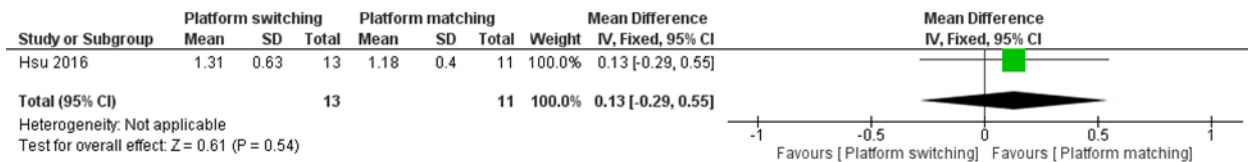


Figure 6: Analysis 1.2. Patient satisfaction at 5 y

In seven studies, all the participants randomized were available for all follow-up duration with no drop outs or exclusions (15,16,18,19,20,21,25). In four studies, the risk of attrition bias was high (14,17,22,24). Two of them performed per-protocol analysis and had drop-outs higher than 10% (17,22) while in the other two discrepancy existed between the reports of the same study regarding the number of patients randomized, and no reply was received from the authors when contacted by email to clarify this issue (14,24). In Rocha (23), the risk of attrition bias was unclear since the trial had 4% drop outs and performed per-protocol analysis.

We assessed five trials to be at high risk of reporting bias due to failure to report key outcomes that are expected to be reported for such studies (14,17,18,22,25), while in all the remaining studies, the risk of bias was low (15,16,19,20,21,23,24).

### Primary outcomes

#### Implant failure

Seven trials reported implant failure (15,16,18,19,21,23,25). There was no difference between platform switching and platform matching in implant failure after 1-3 years of follow up (RR 0.32, 95% CI 0.01 to 7.70; participants = 475; studies = 7;  $I^2 = 0\%$ ) (Analysis 1.1). With a total of 475 implants inserted, only one implant failed, in the platform matched group as shown in figure 5.

#### Patient satisfaction

Three trials assessed patient satisfaction (15,19,24), but only Hsu (19) provided usable data. After one year of follow up, there was no evidence of a difference between the two groups (MD 0.13, 95% CI -0.29 to 0.55; participants = 24; studies = 1;  $I^2 = 0\%$ ) (Analysis 1.2) in figure 6.

### Secondary outcomes

#### Marginal bone loss

Six trials provided data on marginal bone loss (16,17,21-23,25). However, upon pooling down their data together, we identified substantial heterogeneity ( $I^2 = 81\%$ ) with inconsistency in the direction of effect, which was unexplained by clinical or methodological differences between the studies, and accordingly we did not perform meta-analysis since this could produce misleading results.

### DISCUSSION

Twelve RCTs (513 participants) reported the effectiveness of platform switching in patients restored with implant supported fixed restorations on implant failure and patient satisfaction. There was no difference in implant failure and patient satisfaction, and there is insufficient evidence regarding which implant-abutment connection design is more favorable to marginal bone levels.

The studies identified were not sufficient to address the objectives of the review. Although the participants and interventions were relevant to the review question, the outcomes investigated were poorly reported and most of the trials failed to assess the outcomes of interest in the review. In addition, the number of patients in the individual primary studies was relatively small, which increases the risk of random error. There is no consensus currently on the favorable design of the implant-

abutment connection to be used when fabricating implant supported fixed restorations.

The evidence identified do not allow a robust conclusion regarding the effects of platform switching in patients restored with implant supported fixed restorations on implant failure and patient satisfaction. Most of the included trials failed to report the outcomes in a usable form hindering their inclusion in the analysis, and since the studies were of small sample sizes, and there were few events with the CI including appreciable benefit and harm in implant failure and patient satisfaction, we would rate down quality of evidence by two levels for imprecision.

We were able to identify all relevant studies and obtain all relevant data. We did not apply date or language restrictions on our search. Two review authors assessed eligibility for inclusion, carried out data extraction and assessed risk of bias. Accordingly, we are not concerned that the methods used in the review could have introduced bias.

The effectiveness of platform switching have been previously systematically reviewed by 3 articles. (33-35). These reviews concluded that there is significantly less marginal bone loss with the implants restored with platform-switching design. They also stated that there is bone gain after longer follow up periods and with increased mismatch between the implant platform and the abutment. However, the methods of conducting these reviews had the potential of introducing bias, since they included RCTs and observational studies, did not include clinically meaningful outcomes, and combined studies with implants placed at different bone levels. In our review, there was insufficient evidence on the effect of the design on marginal bone loss, and there was no difference between both designs in implant failure or patient satisfaction.

### CONCLUSION

In patients restored with implant supported fixed restorations, there is insufficient evidence to support platform switching or platform matching implant-abutment connection design to improve implant survival and patient satisfaction.

More well-designed randomised controlled trials (RCTs) with appropriate a-priori calculated sample sizes and long follow up durations are required. The trials should focus on clinically relevant outcomes such as the survival of the different prosthetic components and the patient satisfaction with the treatment, and should be reported as recommended by the CONSORT statement ([www.consort-statement.org](http://www.consort-statement.org)).

### Acknowledgements

We would like to thank Professor Ashraf Nabhan Director of Egyptian Center for Evidence Based Medicine (ECEBM) Cairo, Egypt and Dr Marwah Anas El-Wegoud (Co-Director of ECEBM) for providing professional guidance and support on the design, conduct and report of the review. We would like also to thank Dr. Ghada Adayil (department of Oral Medicine and Periodontology Faculty of oral and dental medicine, Cairo University) for the assistance with study screening.

### Funding

No funding received.

## Conflict of Interest

The authors declare that they have no conflict of interest with the content of this article.

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**Table 1: Characteristics of the included studies**

Author	Study design	No. of patients	Age	No. of Implants (PS/PM)	Implant placement parameters	Implant site	Restoration protocol	Marginal bone loss (mean± SD)	Significance
Canullo et al <sup>14</sup>	RCT Multicenter	31	ranged from 36 to 78 years (mean age: 52.1 years).	80	Crestal	In the posterior maxilla.	splinted crowns	<b>Test group1</b> 0.99mm, SD:0.42mm <b>Test group2</b> 0.87mm, SD:0.43mm <b>Test group3</b> 0.64mm,SD: 0.32mm <b>PM</b> 1.48mm,SD: 0.42mm	P≤0.005 P≤0.005 P≤0.005 P≤0.005
De Angelis et al <sup>15</sup>	RCT Multicenter	53	58 years range(55.5 : 61.2) years	79 48/31	Crestal	11 of PS in anterior maxilla 68 in posterior sites	32 single tooth 47 short span	<b>At the 1-year follow-up</b> <b>PS</b> 0.26mm±0.405mm <b>PM</b> 0.31mm±0.432mm	NS NS
Enkling et al <sup>16</sup>	RCT Parallel group	25	51 ± 10.5 years old	50 25/25	Crestal	In the posterior mandible	Single screw- retained crowns	<b>T6: 38 mo</b> <b>PS</b> -0.35 ± 0.50 <b>PM</b> -0.46 ± 0.37	
Fernández-Formoso et al <sup>17</sup>	RCT Parallel group	54	25 pateints Average in PM 34.7 (range 30-68 years) 26 patients Average in PS 42.9 (range 26-69 years)	104 58/56	Crestal	Edentulous areas in maxillary and mandibular premolar and molar regions.	Cemented not-splinted prothesis	<b>PS</b> 0.68 mm (SD 0.88) <b>PM</b> 2.23 mm (SD 0.22)	P < 0.001
Gutmacher et al <sup>18</sup>	RCT Parallel group	27	age ranged from 39 to 75 years (mean age 55.7 1 12.2 years).	41 21/20	Crestal	19 were in the molar region, 18 in the premolar region, and 4 in the anterior region	Single screw- retained crowns	<b>At baseline</b> <b>PS</b> 0.98 ± 0.37 <b>PM</b> 0.69 ± 0.20  <b>At 1 year</b> <b>PS</b> 0.14 ± 0.12 <b>PM</b> 0.94 ± 0.36	.3379   .0025
Hsu et al <sup>19</sup>	RCT Parallel group	26	Mean age of 57.73 ± 12.64 years (range, 31 to 90 years)	26 13/13	Crestal	In test group Anterior (3) Premolar (10) In control group anterior (6) Premolar (7)	Single crown	<b>T1-T2</b> <b>PS</b> 0.23 ± 0.36 <b>PM</b> 0.57 ± 0.27 <b>T1-T3</b> <b>PS</b> 0.24 ± 0.57 <b>PM</b> 0.76 ± 0.40 <b>T1-T4</b> <b>PS</b> 0.20 ± 0.50 <b>PM</b> 0.76 ± 0.39 <b>T1-T5</b> <b>PS</b> 0.21 ± 0.56 <b>PM</b> 0.74 ± 0.47	P < .05 P < .05  P < .05 P < .05  P < .01 P < .01  P < .05 P < .05



<b>Meloni et al</b> <sup>20</sup>	RCT Multi-center split mouth	18	Mean age of 48 (range, 28 to 70 years)	36 18/18	Crestal	Molar region	Single crown	<b>6 months</b> PS 0.58 ± 0.17 PM 0.63 ± 0.17 <b>12 months</b> PS 0.84 ± 0.23 PM 0.93 ± 0.26	P=0.14  P= 0.18
<b>Pozzi et al</b> <sup>21</sup>	RCT Split-mouth design	34	The mean age was 52.20 ± 5.34 years (a range of 39 to 59 years)	88	Crestal	The posterior mandible 52 implants were placed in the molar and 36 implants were placed in the premolar area.	Single crown	<b>After 1 year in function (16 months)</b> PS 0.68 (0.34)* PM 1.15 (0.34)* <b>After 3 year in function (40 months)</b> PS 0.83 (0.27)*‡ PM 1.29 (0.42)*‡	P < 0.05  0.000
<b>Prosper et al</b> <sup>22</sup>	RCT Factorial design multi- center split mouth	60	28 (46.7%) were women and 32 (53.3%) were men. The mean patient age was 53.9 years (SD 6.8), with 11.66% of patients ≤ 40 years of age, 20% of patients 41 to 50, 38.33% of patients 51 to 60, and 30% of patients ≥ 61.	360 180/180	Crestal	173 (48.1%) implants were placed in the maxilla (86 with enlarged platforms and 87 controls), and 187 (51.9%) were placed in the mandible (94 with enlarged platform and 93 controls).	Splinted crowns	<b>12 months follow-up</b> PS1,PM1 = MBL ≤ 0 PS2 = 0.013 ± 0.091 PM3 = 0.272 ± 0.367  <b>24 months follow-up</b> PS1, PM1 = MBL ≤ 0 PS2 = 0.045 ± 0.227 PM3 = 0.275 ± 0.467	p = NR    p = NR
<b>Rocha et al</b> <sup>23</sup>	Prospective multicenter RCT	63	Mean age (SD) (years) in test group 52.84 (10.38) In control group 49.97 (14.77)	135 69/66	Crestal	Posterior mandible	single cement-retained crowns	<b>Load to 12 months</b> PS 0.08 ± 0.41 PM -0.06 ± 0.49 <b>12–24 months</b> PS 0.11 ± 0.24 PM -0.01 ± 0.30 <b>24–36 months</b> PS -0.01 ± 0.26 PM -0.04 ± 0.16	NS NS  <0.01 NS NS NS
<b>Telleman et al</b> <sup>24</sup>	RCT Parallel group	92	18–70 years	149 45/47	Crestal	Posterior mandibular and maxillary region	Single crowns	<b>T5m–T16m</b> PS 0.02 (±0.30) PM 0.03 (±0.30)	NS NS
<b>Telleman et al</b> <sup>25</sup>	RCT Split-mouth design	17	53.7 ± 11.7 (21–67)	34 17/17	Crestal	Posterior mandibular and maxillary region	Single crowns	<b>T5m–T16m</b> PS -0.09(10.36) PM -0.01(10.34)	NS NS

**Figure 2: Excluded studies and reasons for exclusion**

<b>Author</b>	<b>Reason(s) for Exclusion</b>
Canullo et al <sup>36,37</sup>	Immediate implant placement Implants were placed at subcrestal level
Canullo et al <sup>38</sup>	Compare different mismatching
Canullo et al <sup>39</sup>	Splinting both test and control implants
Canullo et al <sup>40</sup>	Immediate implant placement
Crespi et al <sup>41</sup>	Immediate implant placement
Guerra et al <sup>42</sup>	Implants were placed at subcrestal level