Platform switching minimises crestal bone loss around dental implants: truth or myth?

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SUMMARY The aim was to assess the role of platform switching (PS) in minimising crestal bone loss around dental implants through a systematic review of the currently available clinical evidence. To address the focused question ‘Does PS minimise crestal bone loss compared with non-platform-switched (NPS) implants?’ PubMed/Medline and Google Scholar databases were explored from 1986 up to and including December 2013 using the following key words in different combinations: ‘bone loss’, ‘dental implant’, ‘diameter’, ‘mandible’, ‘maxilla’ and ‘platform switching’. Letters to the Editor, unpublished data, historical reviews, case reports and articles published in languages other than English were excluded. Fifteen clinical studies were included. In seven studies, PS and NPS implants were placed in both the maxilla and mandible. In 13 studies, implants were placed at crestal bone levels whereas in one study, implants were placed supracrestally. Three studies reported the bucco-lingual (or transversal) width of the alveolar ridge which ranged between 7–8 mm. Seven studies reported that implants placed according to the PS concept did not minimise crestal bone loss as compared with NPS implants. 3D-Implant positioning, width of alveolar ridge and control of micromotion at the implant-abutment interface are the more critical factors that influence crestal bone levels than PS.

KEYWORDS: bone loss, peri-implantitis, platform switching

Accepted for publication 30 April 2014

Introduction

Nearly three decades ago, Albrektsson et al. (1) suggested that a crestal bone loss of 0.1–0.2 mm per annum after implant loading is a normal phenomenon, which occurs due to crestal bone remodelling. Early crestal bone loss may also facilitate the stagnation and proliferation of anaerobic bacteria on exposed implant surfaces, which if left uncontrolled may increase the possibility of further bone loss in future (2). Thus, implants placed at crestal levels are more likely to be associated with a higher risk of implant exposure over period of time as compared with sub-crestally placed implants. The occurrence of such bone loss may compromise the long-term prognosis of the implant and if extensive, may ultimately cause implant failure. Various factors that have been reported to influence crestal bone loss include periodontal biotype (3, 4), bone density and formation of biological width (5), implant placement depth (6), interimplant distance (7), implant micro- and macro-design (8, 9), occlusal overloading (10) and surgical trauma (11). Although minimising crestal bone loss is essential for the long-term success and survival of implants; this objective continues to challenge clinicians and researchers as no authoritative treatment protocol in this regard exists in indexed literature (12).

In implant dentistry, the concept of platform switching (PS) is based on the placement of a narrow diameter abutment on a wider diameter implant. Implants placed according to the PS concept have implant-abutment junction placed closer to the centre...
of the implant (horizontal mismatch). Studies (13–17) have reported that implants placed according to this concept undergo minimal peri-implant bone loss as compared with non-platform-switched (NPS) implants (that is, implants with matching abutment and implant body diameters). In a systematic review, Al-Nsour et al. (18) supported the effect of PS on minimising peri-implant marginal bone. Results from this study (18) demonstrated that PS is a useful technique in minimising peri-implant bone loss as use of abutments with smaller diameter than their corresponding implant platform diameter exerts favourable effects on peri-implant marginal bone levels. Likewise, results from a prospective RCT (16) showed that irrespective of the surgical technique (one-stage or two-stage implant placement), implants placed according to the PS concept exhibited significantly less bone loss within the first 2 years of placement compared with NPS implants. However, controversial results have also been reported. Results by Enkling et al. (19–21) showed no significant influence of PS in minimising crestal bone loss compared with NPS implants. Clinical results by Romanos et al. (22) emphasised that control of micromotion at the implant-abutment connection (IAC) plays a more critical role in maintaining crestal bone levels than PS. The study concluded that crestal bone loss around immediately loaded platform-switched dental implants (placed at bone level) seem to be associated with implant platform shape and diameter under the requirement that abutments are not removed (22). Similar results were reported in a long-term RCT (23).

Based on the previous controversial results (19–23) that have been reported regarding the efficacy of platform-switched implants in minimising bone loss, it is speculated that the significance of implants, placed according to the PS concept remains dubious. The aim of this study was to assess the role of PS in minimising peri-implant bone loss through a systematic review of currently available evidence.

**Materials and methods**

**Focused question**

The addressed focused question was ‘are dental implants placed according to the PS concept more effective in minimising crestal bone loss as compared with NPS implants?’

**Eligibility criteria**

The following eligibility criteria were applied: (i) original studies; (ii) clinical and randomized controlled trial (RCT) studies; (iii) intervention: role of implants placed according to the PS in minimising crestal bone loss; (iv) inclusion of a control group; and (v) articles published only in English language. Letters to the Editor, experimental studies, case reports, commentaries, review articles and unpublished studies were not sought.

**Search strategy**

PubMed/Medline (*) and Google Scholar databases were searched from 1986 up to and including December 2013 using the following key words in different combinations: ‘bone loss’, ‘dental implant’; ‘diameter’, ‘mandible’, ‘maxilla’ and ‘platform switching’. Titles and abstracts of studies that fulfilled the eligibility criteria were screened and checked for agreement. Full texts of studies judged by title and abstract to be relevant were read and independently assessed in accordance with the eligibility criteria. In addition, hand-searching of the reference lists of potentially relevant original and review studies was also performed and checked for agreement via discussion among the authors.

The initial search yielded 20 studies. Five studies did not fulfil the eligibility criteria and were excluded (see Appendix A). In total, 15 studies (8, 13–17, 19–27) were included and processed for data extraction.

**Results**

**Characteristics of the studies included**

All studies (8, 13–17, 19–27) were performed at university settings. The numbers of participants ranged between 8–80 patients, and the numbers of implants placed ranged between 50–360 implants. In these studies (8, 13–17, 19–27), implants with abutment diameters and platform diameters ranging between 3.3–6 mm and 3.8–5.5 mm were used, respectively. The average post-implant insertion healing period was ~4 months. Post-implant insertion follow-up periods ranged between 12–62.5 months (Table 1). Canullo...
et al. (8, 24, 25, 27) assessed crestal bone loss around maxillary platform-switched implants, and in four studies (15, 19–21), the role of PS in minimising crestal bone loss was assessed around implants placed exclusively in posterior mandible. In seven studies (13, 14, 16, 17, 22, 23, 26), platform-switched implants were placed in the posterior maxilla and mandible (Table 1).

Out of the 15 studies (8, 13–17, 19–27) included, seven studies (8, 19–23, 26) reported that implants placed according to the PS concept do not reduce crestal bone loss as compared with NPS implants. Enkling et al. (19), Romanos et al. (22) and Canullo et al. (25) reported the bucco-lingual widths of the alveolar ridge, which were 7 mm, at least 8 mm and 7 mm, respectively. In 13 studies, (8, 14–17, 19–25, 27) implants were placed at crestal bone levels whereas in one study (26), implants were placed in fresh extraction sockets. In the study by Fernandez-Formoso et al., (13) depth of implant placement remained unclear (Table 2).

Discussion

From the literature reviewed, nearly 50% studies (8, 19–23, 26) reported no significant difference in crestal bone levels among platform-switched and NPS implants. Studies (28, 29) based on PS concept usually credit the geometry of platform-switched implants in contrast to NPS implants in terms of minimising bone loss. However, contradictory results were reported by Canullo et al. (8). In this study (8), implants with abutment diameter 3-8 mm were placed on a platform 4-3 mm in diameter (Group 1). In Group 2, implants with abutment diameter 4-3 mm were placed on a platform 4-8 mm in diameter. The 18 month follow-up results showed no significant difference in mean crestal bone loss around implants in both groups. These authors suggested that bone resorption is most likely related to biological factors, such as biological width re-establishment, rather than to biomechanical factors, such as implant platform diameter (8).

A critical parameter that remained unaddressed in the methodology of most studies (8, 13–17, 20, 21, 23, 24, 26) included in the present review is the transversal width of the alveolar ridge. Implants (whether platform-switched or NPS) placed in narrow ridges are more likely to exert pressure on the buccal plate of the alveolus thereby constricting the buccal blood vessels and compromising the vascular supply to the region as compared with implants placed in arches with wider transverse widths. This is commonly associated with an increased crest bone loss and compromised soft tissue architecture around implants. It is noteworthy that in studies by Enkling et al. (19), Romanos et al. (22) and Crespi et al. (26) implants with body diameters ranging between 3-3–5-5 mm were placed in ridges with widths of 7–9 mm. However, results from these clinical trials (19, 22, 26) reported no significant difference in platform-switched and NPS implants in terms of preservation of crestal bone levels. These results (19, 22, 26) suggest that wide ridges facilitate implant (whether platform-switched or NPS) placement without jeopardising the buccal vascular supply and crestal bone height in the region. Interestingly, Canullo et al. (25) reported significantly more bone loss around NPS implants compared with platform-switched implants placed in a ridge with 7 mm width; however, a limitation of this study (25) was that radiographic evaluation only assessed the mesial and distal bone level, whereas buccal and oral bone levels remained uninvestigated.

In an experimental study on dogs, Abrahamsson et al. (30) investigated the effect of repeated abutment removal and fixation on peri-implant marginal connective tissues (CT). In this study (30), abutments on the test side were removed and re-connected 5× throughout the 6 month study period whereas implant abutments on the control side remained undisturbed. The results demonstrated that repeated abutment removal and reconnection resulted in significantly more soft tissue recession on the test side (about 1.5 mm) as compared with the control side (approximately 0.7 mm) (30). An explanation in this regard is that repeated abutment removal and reconnection (for example during the implant-level impressions) induces micromotion at the IAC thereby allowing microleakage and microgap formation (31). In a recent RCT, Romanos et al. (22) assessed crestal bone loss around two platform-switched implant systems (ANKYLOS plus®* and Certain® PREVAIL™†) over a follow-up period of 24 months. At the follow-up, both implant systems demonstrated at least 2 mm

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Table 1. Characteristics of randomized controlled trial studies included

<table>
<thead>
<tr>
<th>Authors et al.</th>
<th>Patients (n)</th>
<th>Implants (n)</th>
<th>Abutment diameter (in mm)</th>
<th>Platform diameter (in mm)</th>
<th>Jaw</th>
<th>Healing period (in months)</th>
<th>Follow-up (in months)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canullo et al. (8)</td>
<td>12</td>
<td>24</td>
<td>Group 1: 3.8</td>
<td>4.3</td>
<td>Posterior maxilla</td>
<td>Up to 3</td>
<td>18</td>
<td>There was no statistically significant difference in BL between implants placed in groups 1 and 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group 2: 4.3</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
<td>PS implants showed 30% less BL as compared with NPS implants</td>
</tr>
<tr>
<td>Vandeweghe and De Bruyn (13)</td>
<td>15</td>
<td>15</td>
<td>4.05</td>
<td>5.5</td>
<td>Posterior maxilla and mandible</td>
<td>3</td>
<td>12</td>
<td>PS implants (test group) showed significantly less crestal BL compared with NPS implants (control group)</td>
</tr>
<tr>
<td>Fernández-Formoso et al. (14)</td>
<td>51</td>
<td>56</td>
<td>Control group (25 patients): 3.3, 4.1 and 4.8</td>
<td>Standard matching diameter NA*</td>
<td>Posterior maxilla and mandible</td>
<td>3</td>
<td>12</td>
<td>PS implants showed significantly less BL as compared with NPS implants (control group)</td>
</tr>
<tr>
<td>Trammell et al. (15)</td>
<td>10</td>
<td>25</td>
<td>Test group: medialized abutment</td>
<td>Control group: non-medialized with matching diameters</td>
<td>Posterior mandible</td>
<td>2</td>
<td>24</td>
<td>PS implants showed significantly less BL as compared with NPS implants</td>
</tr>
<tr>
<td>Prosper et al. (16)</td>
<td>60</td>
<td>360</td>
<td>Control group: 3.8</td>
<td>3.8</td>
<td>Posterior maxilla and mandible</td>
<td>3</td>
<td>24</td>
<td>PS implants showed significantly less BL as compared with NPS implants</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Test group: 3.8</td>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
<td>PS implants (test group) showed significantly less crestal BL compared with NPS implants (control group)</td>
</tr>
<tr>
<td>Telleman et al. (17)</td>
<td>80</td>
<td>80</td>
<td>4 and 5</td>
<td>NA*</td>
<td>Posterior maxilla and mandible</td>
<td>3</td>
<td>12</td>
<td>PS implants showed significantly less BL as compared with NPS implants</td>
</tr>
<tr>
<td>Enkling et al. (19)</td>
<td>25</td>
<td>50</td>
<td>3.3</td>
<td>4</td>
<td>Posterior mandible</td>
<td>3</td>
<td>36</td>
<td>There was no significant difference crestal BL among PS and NPS implants</td>
</tr>
<tr>
<td>Enkling et al. (20)</td>
<td>21</td>
<td>42</td>
<td>3.3</td>
<td>4</td>
<td>Posterior mandible</td>
<td>3</td>
<td>25</td>
<td>The crestal bone-level changes depended on time and not on platform switching</td>
</tr>
<tr>
<td>Enkling et al. (21)</td>
<td>25</td>
<td>50</td>
<td>Test group: 4</td>
<td>Control group: 4</td>
<td>Posterior mandible</td>
<td>3</td>
<td>12</td>
<td>The crestal bone-level changes depended on time and not on platform switching</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Authors et al.</th>
<th>Patients (n)</th>
<th>Implants (n)</th>
<th>Abutment diameter (in mm)</th>
<th>Platform diameter (in mm)</th>
<th>Jaw</th>
<th>Healing period (in months)</th>
<th>Follow-up (in months)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romanos et al. (22)</td>
<td>18</td>
<td>107</td>
<td>NA ²</td>
<td>Test group: 4-8 Control group: 3-5</td>
<td>Anterior mandible</td>
<td>0 (Immediate loading)</td>
<td>24</td>
<td>Platform switching does not prevent or significantly reduce crestal BL</td>
</tr>
<tr>
<td>Romanos et al. (23)</td>
<td>8</td>
<td>66</td>
<td>NA ²</td>
<td>3-5, 4-5 and 5-5</td>
<td>Complete maxilla and mandible</td>
<td>~4</td>
<td>62</td>
<td>Crestal BL occurred around PS implants placed in heavy smokers and non-smokers were comparable (no abutment removal)</td>
</tr>
<tr>
<td>Canullo et al. (24)</td>
<td>22</td>
<td>22</td>
<td>Control group: 5-5 Test Group: 3-8</td>
<td>5-5</td>
<td>Maxilla</td>
<td>2</td>
<td>25</td>
<td>PS implants showed significantly less BL as compared with NPS implants</td>
</tr>
<tr>
<td>Canullo et al. (25)</td>
<td>31</td>
<td>80</td>
<td>3-8</td>
<td>Test group A: 4-3 Test group B: 4-8 Test group C: 5-5 Control group: 3-8</td>
<td>Posterior maxilla</td>
<td>3</td>
<td>33</td>
<td>PS implants showed significantly less BL as compared with NPS implants</td>
</tr>
<tr>
<td>Crespi et al. (26)</td>
<td>45</td>
<td>64 (Control group: 34 NPS implants Test group: 30 PS implants)</td>
<td>Group 1: 3-8 and 5 Group 2: 4-5 and 5-5</td>
<td>NA ²</td>
<td>Posterior maxilla and mandible</td>
<td>0 (Immediate loading)</td>
<td>24</td>
<td>At follow-up, there was no statistically significant difference in BL in the test group (PS implants) and control group (NPS implants)</td>
</tr>
<tr>
<td>Canullo et al. (27)</td>
<td>9</td>
<td>22</td>
<td>3-8</td>
<td>Control group: 3-8 Test group A: 4-3 Test group B: 4-8 Test group C: 5-5</td>
<td>Posterior maxilla</td>
<td>3</td>
<td>36</td>
<td>PS implants showed significantly less crestal BL compared with NPS implants (control group)</td>
</tr>
</tbody>
</table>

BL, Bone loss; NPS, non-platform-switched; NA, not available; PS, platform-switched.

*Mismatch was created using medialized abutment.

†Mismatch for 4 mm and 5 mm diameter implant was 0.35 mm and 0.4 mm, respectively.

²Platform-switched implants were placed; however, the precise abutment diameter was not reported.
of crestal bone loss (11% and 70% of ANKYLOS plus® and Certain® PREVAIL™ systems, respectively) with no significant difference in mid-facial gingival recession between the two implant designs (22). Although these clinical results (22) support the experimental outcomes reported by Abrahamsson et al. (30), it is pertinent to mention that in the study by Romanos et al. (22) crestal bone loss could not have been associated with the IAC microgap because the abutments were never removed and all implants were splinted together (22). Moreover, both the implant designs used in the study by Romanos et al. (22) had Morse-tapered (conical) and internal polygonal abutment connections. However, according to a previous study (32), the superior mechanics of the conical abutment connections help to explain the significantly better long-term stability in the clinical application.

Among the studies included in the present review (8, 13–17, 19–27), implants were crestally placed in 12 studies (8, 14–17, 19–22, 24, 25, 27). Out of these, 50% studies (8, 19–22, 26) reported PS to be ineffective in preserving crestal bone levels. According to Albrektsson et al. (1), a 0.1–0.2 mm of crestal bone loss per annum after loading is a normal phenomenon due to the crestal bone remodelling. Therefore, implants placed at crestal levels are more likely to be associated with a higher risk of implant exposure over period of time as compared with subcrestally placed implants. Results by Veis et al. (33) showed that crestal placement of the IAC resulted in higher marginal bone loss in straight and platform-switched abutments. The study concluded that PS does not benefit bone levels and ‘subcrestal’ placement of the abutment connection is a vital factor that helps minimise crestal bone loss (33). This suggests that subcrestal placement of implants minimises the risk of implant exposure and subcrestal placement of platform-switched implants allows bone stability or growth over the implant shoulder. However, in a recent clinical study providing long-term results, Romanos et al. (6) reported values for minimal marginal bone loss around implants placed at crestal or subcrestal position to be comparable with Morse-tapered connections without abutment removal. Further long-term RCTs are needed in this regard.

A maximum follow-up duration period of 3 years was observed in studies (13–17, 24, 25, 27), which reported PS to be effective in maintaining crestal bone levels. However, in a long-term (at least 62-5 month follow-up) longitudinal clinical trial, Romanos et al. (23) showed that minimal crestal bone loss occurred around PS implants placed in heavy smokers and

<table>
<thead>
<tr>
<th>Authors et al.</th>
<th>Implant placement</th>
<th>Width of alveolar ridge</th>
<th>Biological width</th>
<th>Did platform switching minimise BL?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canullo et al. (8)</td>
<td>Crestal</td>
<td>NA</td>
<td>NA</td>
<td>No</td>
</tr>
<tr>
<td>Vandeweghe and De Bruyn (13)</td>
<td>NA</td>
<td>NA</td>
<td>There was no significant effect of PS on BL when the BW was &lt;6 mm</td>
<td>Yes</td>
</tr>
<tr>
<td>Fernández-Formoso et al. (14)</td>
<td>Crestal</td>
<td>NA</td>
<td>NA</td>
<td>Yes</td>
</tr>
<tr>
<td>Trammell et al. (15)</td>
<td>Crestal</td>
<td>NA</td>
<td>There was no significant difference in BW among PS and NPS implants</td>
<td>Yes</td>
</tr>
<tr>
<td>Prosper et al. (16)</td>
<td>Crestal</td>
<td>NA</td>
<td>NA</td>
<td>Yes</td>
</tr>
<tr>
<td>Telleman et al. (17)</td>
<td>Crestal</td>
<td>NA</td>
<td>NA</td>
<td>Yes</td>
</tr>
<tr>
<td>Enkling et al. (19)</td>
<td>Crestal</td>
<td>At least 7 mm</td>
<td>NA</td>
<td>No</td>
</tr>
<tr>
<td>Enkling et al. (20)</td>
<td>Crestal</td>
<td>NA</td>
<td>NA</td>
<td>No</td>
</tr>
<tr>
<td>Enkling et al. (21)</td>
<td>Crestal</td>
<td>NA</td>
<td>NA</td>
<td>No</td>
</tr>
<tr>
<td>Romanos et al. (22)</td>
<td>Crestal</td>
<td>At least 9 mm</td>
<td>NA</td>
<td>No</td>
</tr>
<tr>
<td>Romanos et al. (23)</td>
<td>Crestal</td>
<td>NA</td>
<td>NA</td>
<td>No</td>
</tr>
<tr>
<td>Canullo et al. (24)</td>
<td>Crestal</td>
<td>NA</td>
<td>NA</td>
<td>Yes</td>
</tr>
<tr>
<td>Canullo et al. (25)</td>
<td>Crestal</td>
<td>At least 7 mm</td>
<td>NA</td>
<td>Yes</td>
</tr>
<tr>
<td>Crespi et al. (26)</td>
<td>Subcrestal</td>
<td>NA</td>
<td>NA</td>
<td>No</td>
</tr>
<tr>
<td>Canullo et al. (27)</td>
<td>Crestal</td>
<td>Wide*</td>
<td>NA</td>
<td>Yes</td>
</tr>
</tbody>
</table>

BL, Bone loss; BW, biological width; NPS, non-platform-switched; PS, platform-switched.

*The precise width of the alveolar ridge was not reported.
non-smokers (~0.5 mm mesially and ~0.4 mm in smokers and non-smokers, respectively) using immediate loading concept (23). It is noteworthy that in the study groups, the implant abutments were never removed and all implants were splinted together immediately after surgery. This seems to have prevented micromotion thereby maintaining crestal bone levels. We hypothesise that earlier studies (13–17, 24, 25, 27) (which reported PS to be effective in maintaining crestal bone levels compared with NPS implants) been continued, they probably would have observed bone loss around PS implants to the same extent as in NPS implants.

A critical factor that may influence the overall efficacy of the implant system under investigation is the choice of radiographs used for assessing bone loss. Gedik et al. (34) reported that bitewing (BW) radiographs show the highest accuracy in the assessment of crestal bone levels as compared with panoramic and periapical (PA) radiographs; whereas, according to Akesson et al. (35), PA radiographs (using the parallel-technique) are more accurate in assessing marginal bone levels in contrast to BW and panoramic radiographs. In this study (35), the underestimation of the bone loss in panoramic, BW and PA radiographs ranged from 13%–32%, 11%–23% and 9%–20%, respectively. Results by Pepelassi and Diamanti-Kipioti (36) also suggested that PA radiography is more reliable in assessing periodontal bone levels as compared with panoramic radiography. It is therefore pertinent to mention that in the study by Enkling et al. (19–21) crestal bone levels around platform-switched and NPS implants were measured on panoramic radiographs. Although these results (19–21) showed no difference in bone loss around platform-switched and NPS implants; there is a possibility that crestal bone levels were imprecisely assessed in these studies (19–21).

Additionally to long-term follow-up studies, more RCTs are needed to control for the other (cofounding) factors discussed in this paper, such as the implant diameter in relation to the bucco-lingual width of the alveolar ridge and the corono-apical implant positioning. Bone changes at the buccal aspect should also be assessed.

**Conclusion**

Role of PS in minimising crestal bone loss remains debatable. Bone loss around implants seems to be governed by several factors, such as the cervical features of the implant design, 3D-implant positioning, prosthetic concept and the IAC, width of alveolar ridge and prevention of micromotion at the implant-abutment interface and not merely placing implants according to the PS concept.

**Conflicts of interest**

The authors declare that they have no conflicts of interest and there was no external source of funding for the present study.

**References**


36. Pepelassi EA, Diamanti-Kipioti A. Selection of the most accurate method of conventional radiography for the assessment

Appendix A. List of excluded studies. Reason for exclusion is shown in parenthesis


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