Influence of Abutment Design and Platform Switching on Peri-implant Marginal Bone Level: A Randomized Controlled Clinical Trial with 1-Year Results

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The purpose of this randomized clinical study was to evaluate the efficacy of platform-switching (PS) vs platform-matching (PM) implants when paired with a newly designed marginless abutment (MA) vs a conventional abutment (CA) in maintaining peri-implant tissue stability. Marginal bone level (MBL) and probing depth were measured up to 1 year postloading. Eighty implants were inserted in 42 patients and randomly assigned to one of four groups, each with a different implant/abutment configuration: Group 1 (PM+CA), Group 2 (PM+MA), Group 3 (PS+CA), and Group 4 (PS+MA). Data were collected at implant placement (T0), abutment placement (T1), final crown placement (T2), and 1 year postloading (T3). At the 1-year follow-up, MBL was more stable in Groups 3 and 4 compared to Groups 1 and 2. These results suggest that the role played by the implant-abutment connection (PS vs PM) is more important than the type of abutment preparation (MA vs CA). Int J Periodontics Restorative Dent 2021;41:547–553. doi: 10.11607/prd.5337

There is evidence that the supracrestal dimension that exists around dental implants contributes to creating the biologic width1–3 (which functions as a tissue barrier), as implant restoration can lead to crestal bone remodeling and thus affects the stability of surrounding tissue.4 Biologic width serves as a protective mechanism for underlying bone and extends apically from the implant-abutment junction.4–7

Multiple approaches and techniques have been studied to understand how to mitigate the adaptive marginal bone level (MBL) remodeling and changes that occur following biologic width establishment.8–10 Past research has shown that the use of platform switching (PS), whereby an abutment is used with a smaller diameter than the original implant platform, may prevent vertical crestal bone loss around implants.5,11 Lazzara and Porter introduced this concept and hypothesized that this decreased loss was likely due to the fact that the biologic width can partially be created in the horizontal dimension.2

Clinical studies have shown promising results using the PS technique.9,11,12 Two different meta-analyses reported that the MBL around PS implants is significantly more stable than around platform-matching (PM) implants.13,14

Abutment morphology may also play an important role in the
stability of gingival margins. When considering tooth preparations and abutment configurations for fixed prosthodontics, there are several options, including horizontal preparation with a defined abutment margin (shoulder or chamfer designs) or with a vertical preparation (feather edge). Traditional abutment design for cement-retained implant restorations has replicated natural teeth prepared for crown restorations with similar tapers and chamfer finishing lines.

A fixed prosthodontic margin design called biologically oriented preparation technique (BOPT) has been introduced, utilizing feather-edge preparations on natural teeth. Clinical reports using the same technique for teeth and implants in the esthetic rehabilitation of a maxillary anterior segment have been described. Later, a hybrid abutment design that includes a combination of two types of margin finish lines was described: a feather edge on buccal surfaces and a chamfer finish line on lingual surfaces. When reporting on the use of the BOPT in abutments for implant-supported fixed prostheses, it was concluded that vertical preparation of abutments without finish lines was an appropriate technique for the preservation, remodeling, and stability of peri-implant tissues.

Taken together, while it appears that using the PS technique leads to more favorable preservation of peri-implant bone, further research is warranted regarding type and design of abutment for optimal outcomes. Recently, a newly designed titanium abutment (Tissuemax, Bio-max) with a vertical and marginless preparation has been introduced, intending to modulate the soft tissue integration around implant-supported crowns. Many of the studies to date, however, are based on case reports or small sample sizes and are without control comparators.

The purpose of this randomized clinical study was to evaluate the use of PS vs PM when paired with a newly designed marginless abutment (MA) vs a conventional abutment (CA). Outcomes of interest were peri-implant MBL and probing depth (PD) at up to 1 year after occlusal loading.

Materials and Methods

Forty-two consecutive adult patients needing a total of 80 implants were selected from the pool of a periodontal specialist private practice and gave informed consent to participate. The study protocol was approved by the ProEd Ethical Committee in Torino, Italy, and registered on clinicaltrials.gov (ID: NCT01807416). The study, conducted in accordance with Helsinki Declaration of 1975 as revised in 2008, was a randomized controlled clinical trial designed following the guidelines from the Consolidated Standards of Reporting Trials (CONSORT) statement. A total of 80 implants were placed (T3 Tapered Certain, Zimmer Biomet), using a single-stage procedure with transmucosal healing. Implants were placed in premolar or molar areas in completely healed sites in both arches. Abutments were either CA (GingiHue Abutment, Zimmer Biomet) or MA (Tissuemax).

Each implant was randomly assigned to one of four different groups (n = 20 implants per group; Fig 1) using a computer-generated randomization list (SPSS version 16, IBM). Each group had a different implant/abutment configuration (Figs 2 to 5):

- Group 1: platform matching + conventional abutment (PM+CA)
- Group 2: platform matching + marginless abutment (PM+MA)
- Group 3: platform switching + conventional abutment (PS+CA)
- Group 4: platform switching + marginless abutment (PS+MA)

Implants were placed (T0) with diameters of 4 or 5 mm, and abutment diameters were 3.25, 4, or 5 mm. Twelve weeks after implant placement, definitive prosthetic abutments and temporary crowns were delivered (T1). Definitive porcelain crowns were cemented after 8 more weeks (T2), using a temporary cement (Temp-Bond, Kerr) with special attention to remove any excess. Final outcomes were collected at 1 year postloading (T3; Fig 6).

At each data collection time point (Table 1), the primary outcome of interest (MBL) was evaluated and measured on standardized intraoral radiographs. Radiographs were made using the long-cone parallelizing technique with a Rinn film holder and taken using a digital video-radiography system with charged coupled–device sensors (Sidexis...
Enrollment

Assessed for eligibility (n = 80)

Excluded (n = 0)

Allocation

Randomized (n = 80)

Allocated to Group 1 (n = 20): platform-matching + conventional abutment (PM+CA)

Allocated to Group 2 (n = 20): platform-matching + marginless abutment (PM+MA)

Allocated to Group 3 (n = 20): platform-switching + conventional abutment (PS+CA)

Allocated to Group 2 (n = 20): platform-switching + marginless abutment (PS+MA)

Follow-up

Lost to follow-up (n = 0)

Lost to follow-up (n = 0)

Lost to follow-up (n = 0)

Lost to follow-up (n = 0)

Analysis

Analyzed (n = 20)

Analyzed (n = 20)

Analyzed (n = 20)

Analyzed (n = 20)

Fig 1 Flowchart of the study groups through parallel randomized trial.

Fig 2 (a) Implant-abutment configuration of Group 1 (PM+CA). (b) Microscopically enhanced view.

Fig 3 (a) Implant-abutment configuration of Group 2 (PM+MA). (b) Microscopically enhanced view.

Fig 4 (a) Implant-abutment configuration of Group 3 (PS+CA). (b) Microscopically enhanced view.

Fig 5 (a) Implant-abutment configuration of Group 4 (PS+MA). (b) Microscopically enhanced view.
Fig 6. Clinical and radiographic views of an example case at different time points. (a) Baseline (T0). (b) Healing abutment connected after implant placement. (c) Transmucosal area before the connection of the definitive titanium abutment. (d) Titanium abutment after connection. (e) Provisional crown cemented (T1). (f) Definitive ceramic crown after cementation radiologic examination (T2). (g) Ceramic crown at the 1-year follow-up (T3).

Table 1. Marginal Bone Level (MBL) as Measured at Each Time Point

<table>
<thead>
<tr>
<th></th>
<th>T0</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>P</th>
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<tbody>
<tr>
<td>Group 1:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PM+CA</td>
<td>-0.08 ± 0.49</td>
<td>0.43 ± 0.39</td>
<td>0.55 ± 0.42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.57 ± 0.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>Group 2:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM+MA</td>
<td>-0.10 ± 0.52</td>
<td>0.39 ± 0.57</td>
<td>0.46 ± 0.61&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.49 ± 0.61&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>Group 3:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS+CA</td>
<td>-0.02 ± 0.23</td>
<td>0.18 ± 0.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.24 ± 0.26&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>0.28 ± 0.26&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>Group 4:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS+MA</td>
<td>0.01 ± 0.09</td>
<td>0.21 ± 0.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.24 ± 0.20&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>0.28 ± 0.22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt; .05</td>
</tr>
</tbody>
</table>

CA = conventional abutment; MA = marginless abutment; MBL = marginal bone level; NSD = no statistical difference; PM = platform-matched; PS = platform-switched; T0 = implant placement; T1 = crown and abutment delivery; T2 = crowns cemented; T3 = 1 year postloading.

Values are reported in millimeters as mean ± SD. Data with the same superscript letter have no statistical difference.

XG, Dentsply Sirona), and directly acquired into a dedicated software program (Sidexis neXt Generation version 1.52, Dentsply Sirona). The software was calibrated for each image using the known length of the implant. Linear measurements on the digital radiographs were performed by a single, previously calibrated examiner (L.T.) using the measurement tool specifically designated in the software. MBL was defined as the distance from the alveolar bone in direct contact with the implant surface at the mesial...
and distal aspects of the implants to the implant shoulder (level of abutment connection; Fig 7). The secondary outcome of interest was PD measured at the following implant locations: mesial, buccal, distal, and lingual.

PM implants had either a 4- or a 5-mm diameter and a prosthetic platform of 4.1 or 5.0 mm, respectively. The PS implant group consisted of 4- or 5-mm–diameter implants but with a 3.4- or 4.1-mm restorative platform, respectively.

Statistical Analysis

Differences within and between the four treatment groups were analyzed using Friedman and Kruskal-Wallis tests, with a significance level established as $P < .05$.

Results

Mean patient age was 56.2 years (range: 29 to 84 years). As planned, 20 implants were placed per group. Implant insertion torque values were at least 25 Ncm, and none of the implant sites required bone grafting. All implants osseointegrated and were clinically stable at the 1-year follow-up, with a success rate of 100% per Albrektsson’s criteria. MBLs are reported in Table 1. The difference in MBL between baseline and the 1-year follow-up (Table 2) was $0.65 \pm 0.15$ mm for Group 1 (PM+CA), $0.59 \pm 0.29$ mm for Group 2 (PM+MA), $0.30 \pm 0.23$ mm for Group 3 (PS+CA), and $0.27 \pm 0.19$ mm for Group 4 (PS+MA). No statistically significant difference in MBL was found between Groups 1 and 2 (PM groups), and between Groups 3 and 4 (PS groups). However, the results from Groups 1 and 2 were statistically different from the results from Groups 3 and 4 (Table 2).

Regarding PD (Table 3), no statistically significant differences were found between T1 and T3 values in all four groups. At T1, no statistically significant differences were found between Groups 2 and 3, Groups 2 and 4, and Groups 3 and 4. However, the results from Group 1 (PM+CA) presented higher values and were statistically different when compared to the other groups.

Discussion

In the present report, use of PS implants showed favorable results (stability of MBL) when compared to the PM implants. This finding mirrors the experiences of other researchers; a recent review of six
meta-analyses on this subject indicated that PS implants preserved more bone compared to PM implants (mean differences of –0.29 mm and –0.49 mm, respectively). Another recent study on 146 implants followed patients for 5 years after functional loading: PS implants presented a mean MBL difference of 0.23 mm. The authors concluded that use of PS healing abutments likely contributes to the stability of peri-implant tissues.21 As described by Cochran et al in 2013, there is a different biologic response to implants when nonmatching implant-abutment diameters are used (PS), as the resulting biologic reaction indicates that marginal inflammation is eliminated or greatly reduced.22 In addition to the influence of platform type, both soft and hard tissue recession has been associated with abutment shape. When an abutment is used that places the biologic width more coronally, the width has an opportunity to become thicker and more stable.23 While very little research has been conducted with the MA used in this study, initial results show favorable responses. As Cocchetto and Canullo noted, a feather-edge MA has shown positive

<table>
<thead>
<tr>
<th>Group 1: PM+CA</th>
<th>T1–T0</th>
<th>T2–T0</th>
<th>T3–T0</th>
<th>T2–T1</th>
<th>T3–T1</th>
<th>T3–T2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.52 ± 0.18a</td>
<td>0.63 ± 0.16a</td>
<td>0.65 ± 0.15a</td>
<td>0.12 ± 0.14</td>
<td>0.13 ± 0.14</td>
<td>0.02 ± 0.05</td>
</tr>
<tr>
<td>Group 2: PM+MA</td>
<td>0.48 ± 0.28a</td>
<td>0.56 ± 0.28a</td>
<td>0.59 ± 0.29a</td>
<td>0.08 ± 0.12</td>
<td>0.10 ± 0.16</td>
<td>0.03 ± 0.06</td>
</tr>
<tr>
<td>Group 3: PS+CA</td>
<td>0.20 ± 0.17b</td>
<td>0.26 ± 0.23b</td>
<td>0.30 ± 0.23b</td>
<td>0.07 ± 0.11</td>
<td>0.10 ± 0.12</td>
<td>0.03 ± 0.05</td>
</tr>
<tr>
<td>Group 4: PS+MA</td>
<td>0.20 ± 0.13b</td>
<td>0.23 ± 0.16b</td>
<td>0.27 ± 0.19b</td>
<td>0.03 ± 0.06</td>
<td>0.07 ± 0.10</td>
<td>0.04 ± 0.06</td>
</tr>
</tbody>
</table>

CA = conventional abutment; MA = marginless abutment; NSD = no statistical difference; PM = platform-matched; PS = platform-switched; T0 = implant placement; T1 = crown and abutment delivery; T2 = crowns cemented; T3 = 1 year postloading. Values are reported in millimeters as mean ± SD. Data with the same superscript letter have no statistical difference. Differences among and between groups were analyzed using Friedman and Kruskal-Wallis test, with \( P < .05 \) indicating statistical significance. No statistical difference was found between Groups 1 and 2, and between Group 3 and 4. However, the data of Groups 1 and 2 were statistically different with the data of Groups 3 and 4.

<table>
<thead>
<tr>
<th>Group 1: PM+CA</th>
<th>T0</th>
<th>T1</th>
<th>T3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.11 ± 0.65</td>
<td>3.01 ± 0.59</td>
<td>3.06 ± 0.53</td>
<td>NSD</td>
</tr>
<tr>
<td>Group 2: PM+MA</td>
<td>2.81 ± 0.50</td>
<td>2.79 ± 0.42</td>
<td>2.84 ± 0.39b,c</td>
<td>NSD</td>
</tr>
<tr>
<td>Group 3: PS+CA</td>
<td>2.79 ± 0.41</td>
<td>2.71 ± 0.36</td>
<td>2.69 ± 0.30a,c</td>
<td>NSD</td>
</tr>
<tr>
<td>Group 4: PS+MA</td>
<td>2.66 ± 0.34</td>
<td>2.68 ± 0.36</td>
<td>2.63 ± 0.31b,c</td>
<td>NSD</td>
</tr>
</tbody>
</table>

CA = conventional abutment; MA = marginless abutment; NSD = no statistical difference; PM = platform-matched; PS = platform-switched; T0 = implant placement; T1 = crown and abutment delivery; T3 = 1 year postloading. Values are reported in millimeters as mean ± SD. Data with the same superscript letter have no statistical difference. In all four groups, no statistically significant difference was found between T1 and T3. At the 1-year follow-up, no statistically significant difference was found between Groups 2 and 3, between Groups 2 and 4, and between Groups 3 and 4. However, the data of Group 1 was statistically different from the other three groups.
effects in terms of gingival margin stability, with potential thickening of the buccal gingival tissue. The results of the present study seem to support this finding, as the PD was greater in the PM+CA (Group 1) but not in the other tested groups. Additionally, the MBL in this study was lower in cohorts treated with MA than those treated with CA.

Conclusions

At 1-year follow-up, MBL was more stable in the groups with PS compared to the groups with PM. It seems that the influence of the implant-abutment connection (PS vs PM) was more important than the type of abutment preparation (MA vs CA). The results suggest that the use of PS (with both MA and CA) and use of MA (with both PS and PM) may positively influence the results in terms of MBL stability.

Acknowledgments

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References