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This prospective clinical study involved 20 patients in whom implants were immediately placed in extraction sockets. Residual bone defects were grafted, and the buccal bone plate was overcontoured with a xenogeneic bone substitute and covered by a collagen membrane. One year after implant placement, CBCT images were acquired to evaluate buccal bone, and implant stability was analyzed through resonance frequency analysis. Results showed that buccal bone covered the rough surface of all implants 1 year after implantation. Hard tissues responded more favorably in the flapless group. No correlation was found between initial bone defects and bone dimensions in the follow-up exam. Int J Periodontics Restorative Dent 2022;42:331–339. doi: 10.11607/prd.4619

For the replacement of teeth in the anterior maxilla using implants, current studies reveal high survival rates for immediate and late implant placement, suggesting an equivalence of results between the two approaches. The current literature suggests the main indication for immediate implant placement is the presence of alveolar integrity, especially at the buccal wall of the socket, thereby relegating all cases with defects to a deferred or early implant placement. The purpose of this study was to evaluate the integrity and stability of the facial bone wall in cases with immediately placed single-tooth implants, with simultaneous bone augmentation compensating the alveolar remodeling process (performed with and without flaps), in the anterior maxilla. The clinical importance of this study is the decreased treatment times and morbidity seen with this approach compared to early implant placement after 4 to 8 weeks of soft tissue healing (type 2).

Materials and Methods

This prospective case series study evaluated the effectiveness of immediate single implant placement with simultaneous contour augmentation in postextraction sockets that...
were defect-free, or had a dehiscence ≤ 3 mm, located in the anterior maxilla (canine to canine), with or without flap reflection.

The inclusion criteria were as follows: (1) patients of either sex, aged between 20 and 60 years and in good health; (2) willingness to participate in and complete the study and provide consent; (3) replacement sites have healthy neighboring teeth, without bone loss or periodontal processes; (4) intact socket walls, or with dehiscence ≤ 3 mm involving only the buccal bone wall; (5) healthy gingival tissue; (6) absence of acute infection at the extraction site; and (7) availability of apical and palatal socket bone to place a standard implant (3.8-mm diameter, 12 to 15 mm length) detectable by CBCT evaluation.

The exclusion criteria were as follows: (1) systemic disease that could compromise postsurgical wound healing, such as uncontrolled diabetes mellitus; (2) alcoholism; (3) local infection or insufficient bone to place an immediate implant detectable by CBCT evaluation; (4) previous bone graft procedures in the study area; (5) pregnancy; (6) history of radiation therapy in the head or neck region; (7) history of chemotherapy within 5 years prior to surgery; and (8) smoking > 10 cigarettes a day and any drug/alcohol abuse. Each patient was informed in detail about the implant treatment received and signed an informed consent form.

The study was conducted in accordance with the principles described in the 1975 Declaration of Helsinki on clinical research in humans (as revised in 2008) and was approved (Acta N-114) by the Institutional Committee on Ethics in Health Research, Faculty of Dentistry of the National University of Córdoba, Argentina.

Twenty implants were placed (Tapered Plus, BioHorizons). Anorganic bovine bone mineral matrix granules (MinerOss X, BioHorizons) and resorbable collagen membranes (Mem-Lok, BioHorizons) were used in the procedures. Group 1 patients (n = 10) underwent flap surgery, whereas Group 2 patients (n = 10) received flapless surgery. Distribution bias was prevented by blind randomization of cases. The sample sizes were determined to be 10 patients per group following a clinical evaluation of 50 patients who presented to the postgraduate program over 1 year. The implants used were 3.8 mm in diameter and 12 to 15 mm in length, and two clinical protocols were implemented according to each study group.

**Group 1 (Flap)**

Group 1 underwent tooth extraction with a vertical, less-traumatic system (Benex Control Root Extraction System, Meisinger). An incision was made with a 15C scalpel blade at the level of the gingival sulcus of the mesial neighboring tooth, and a releasing incision was made distally to the distal adjacent tooth without involving papilla, followed by full flap reflection. The implant was three-dimensionally positioned and placed in an ideal prosthetic position, as dictated by the surgical template. Resonance frequency analysis (Osstell) was used to measure primary stability, and a torque wrench (BioHorizons) was used to measure insertion torque. A 15C scalpel blade was used to release a periosteal flap with, and healing abutments (3.0-mm platform, titanium alloy, 3-mm collar height; BioHorizons) were placed at the soft tissue level. Autologous bone was then placed on the exposed implant surface, obtained (1) by scraping the neighboring area with a periodontal bone chisel (Back Action, Hu-Friedy) and (2) with the drill bit used for implant placement. A mineral matrix of anorganic bovine bone granules was placed in the gap, on the autologous bone previously arranged on the implant, and on the outside of the buccal table, overcontouring it about 2 mm thick. A trimmed and adapted resorbable collagen membrane was then placed over the granules. Vertical and horizontal mattress sutures were made, crossing the papillae and the midline of the implant socket, respectively, to secure the membrane (Fig 1).

**Group 2 (No Flap)**

The treatment Group 2 is distinguished by a full-thickness, flapless buccal pocket syndesmotomy (10 mm deep) to allow the procedure to be performed. A trimmed and adapted resorbable collagen membrane was placed into the full-thickness buccal pocket.
syndesmotomy. Autologous bone (obtained from the drill used for implant placement) was placed on the exposed implant surface. A mineral matrix of anorganic bovine bone granules was placed in the gap, on the autologous bone previously arranged on the implant, and on the outside of the vestibular table, (between the collagen membrane and the buccal bone), overcontouring it about 2 mm thick. The implant cap that prevents bone filling from penetrating into the implant was removed, and a healing abutment was placed at the soft tissue level. Horizontal mattress sutures were used to contain the buccal soft tissue (Fig 2).

Initial Assessment

Buccal bone thickness
To measure the hard tissue buccal bone thickness (BBT), a CBCT scan was performed with 90 kV, 10 mA, and a cycle of 18-second exposure using ProMax 3D Plus (Planmeca). The images obtained were analyzed with Romexis (version 4.4.0.R, Planmeca). For the CBCT, a 40 × 50–mm field of view was used with an isotropic voxel size of 75 µm (0.075 mm). The obtained images were visualized and analyzed with Romexis. Separate 0.5-mm-thick cuts were analyzed, encompassing the root cervical third, 4 mm apical to the buccal cementoenamel junction, root middle third, 6 mm apical to the buccal cementoenamel junction, root apical third, and 8 mm apical to the buccal cementoenamel junction.

Alveolar ridge thickness
Alveolar ridge thickness (ART) was measured by CBCT 6 mm apical to the buccal cementoenamel junction. Alveolar defect measurement and clinical classification followed the methodologies proposed by Benic et al14 and Kuchler et al.25 The following intrasurgical measurements of the residual bone defect were performed in the midbuccal aspect of the
implant using a periodontal probe with markings every millimeter: (1) distance (mm) from the implant shoulder to the alveolar crest (IS–AC); (2) distance (mm) from the implant shoulder to the first bone-to-implant contact (IS–BIC); and (3) horizontal defect depth (mm) from the implant surface to the more coronal aspect of the alveolar crest in a direction perpendicular to the implant’s long axis (HDD) (Fig 3).

The insertion stability was recorded at the time of implant placement. A minimum value was not established for the inclusion criteria; only the implant should have primary stability.

**Follow-up Assessment**

Patients were followed up 1 year after the start of the procedures. The defect volume was evaluated according to the initial intrasurgical midbuccal measurement of the alveolar residual bone defects and by CBCT.

BBT was measured at the level of the cervical third (2 mm from IS), middle third (4 mm from the IS), and apical third (6 mm from the IS) (Fig 4a). Unlike the initial assessment, ART was measured 4 mm apical from the implant shoulder at follow-up assessments (Fig 4b). For the scanning procedure, the occlusal planes were oriented parallel to the horizontal plane. To perform comparative measurements, the protocols for the registration of medical images were followed. First, the images were uploaded to the MatLab R 2018 matrix calculation program to establish a correspondence relationship between them, following the process of superimposing the CBCT images using the Canny Edge search module of MatLab R2018 (64-bit). Overlays were made in the areas of interest by obtaining identical reference points provided by the Canny filter: IS–AC (Fig 4c), IS–BIC (Fig 4d), and HDD. CBCT measurements were made independently by three examiners (P.N., D.T., and E.F.B.); each measurement was
Fig 3  Baseline intrasurgical measurement of residual bone at the midbuccal aspect of an implant. 1 = Distance (mm) from the implant shoulder to the alveolar crest (IS–AC). 2 = Distance (mm) from the implant shoulder to the first bone-to-implant contact (IS–BIC). 3 = Horizontal defect depth (mm) from the implant surface to the most coronal aspect of the alveolar crest in a direction perpendicular to the implant’s long axis (HDD).

Fig 4  CBCT scans of the midbuccal aspect of an implant at the 1-year follow-up. (a) Buccal bone thickness (BBT), measured at the cervical, middle, and apical thirds. (b) Alveolar ridge thickness (ART), measured 4 mm apical from the implant shoulder. (c) Distance from the implant shoulder to the alveolar crest (IS–AC). (d) Distance from the implant shoulder to the first bone-to-implant contact (IS–BIC).
repeated three times, and the mean was calculated. Implant stability was assessed by resonance frequency analysis at the 1-year follow-up by removing the screwed restoration. The definitive prosthetic restoration was a custom-milled CAD/CAM zirconia crown cemented on the titanium base abutment (BioHorizons), then screw-retained to the implant.

**Study Variables and Statistical Analyses**

Intergroup differences were assessed by Mann-Whitney nonparametric test. Spearman nonparametric correlation tests were used for correlation analysis. For all tests, statistical significance was set to .05.

**Results**

A total of 20 patients (12 women, 8 men) with a mean age of 49.2 years (range: 23 to 59 years) attended the 1-year follow-up examination. None of the patients in the present study were smokers.

Twelve implants were placed in the central incisors, 7 in the lateral incisors, and 1 in a maxillary canine. All implants were 3.8 mm in diameter; 14 implants were 12 mm long and 6 implants were 15 mm long.

**BBT**

Appendix Table 1 (available in the online version of this article at quintpub.com/journals) shows BBT values according to third (cervical, middle, or apical), group, and stage (pre-treatment or 1-year follow-up), and differences between stages were calculated for the two study groups. Pretreatment BBT values were similar for both groups. At 12-month follow-up, Group 2 registered the highest mean values, particularly in the middle third (4 mm from the implant shoulder). To determine the increase in BBT experienced at each third, interstage differences were calculated for each case (preoperative BBT – 1-year BBT). The analysis showed nonsignificant differences (cervical: \( P = .075 \); middle: \( P = .089 \); apical: \( P = .796 \)), although the largest bone thickness was associated with the flapless group, especially in the cervical and middle thirds. Differences between groups were also nonsignificant when comparing the average BBT gains for the three thirds combined (\( P = .143 \)). Results show that buccal bone covering the rough surface of the implant was found in all cases.

**ART**

CBCT was used to measure ART 4 mm apical from the implant shoulder at follow-up assessments. Appendix Table 2 shows absolute and comparative pre- and posttreatment ART values (mean ± SD) by group and stage. Mean thickness increased 1 year after treatment in both groups, but it was somewhat larger in the flapless group (flap: 8.3 mm; no flap: 10.1 mm). No significant differences were found in ART thickness between treatment stages (Mann-Whitney test, \( P = .063 \)).

**IS–AC**

Appendix Table 3 describes comparative IS–AC measurements by group and stage. Interstage differences were more noticeable in the flapless group (1.64 mm, vs 0.77 mm in the flap group). Within both groups and in most cases, the IS–AC distances recorded at 1 year were positive, with the buccal alveolar bone crest located above the implant shoulder. In contrast, at the initial stage, all of these values were \( \leq 0 \). When comparing the extent of remodeling (interstage IS–AC differences), no significant differences between treatment groups were found (Mann-Whitney test, \( P = .218 \)).

**IS–BIC**

Appendix Table 4 shows IS–BIC measurements by group and stage, and differences between stages for the two study groups. At 1 year, all intergroup distances lay within a very narrow range of values (between 0 and –1.1 mm). Distributions of the differences in IS–BIC between stages were similar and did not differ significantly among the groups (Mann-Whitney test, \( P = .315 \)).

**HDD**

Appendix Table 5 shows HDD measurements by group and stage as well as differences between stages for the two study groups. All HDD values were 0 mm at the 1-year follow-up, so the differences between stages match pretreatment.
values for each group. Intergroup differences in HDD between stages were not significantly different (Mann-Whitney test, \( P = .165 \)).

**Implant Stability**

Appendix Table 6 lists the implant stability quotients (ISQs) according to group and stage, as well as the differences between them. ISQ distributions were similar in both groups both in the pre- and post-treatment stages, with a marked increase in implant stability noted 1-year postimplantation. No ISQ differences were detected among groups at each stage, although significant differences were noted between stages (\( P = .0003 \)). The insertion torque values were between 20 N and 50 N.

**Discussion**

It is important to emphasize that the xenograft material was applied (1) within the gap between the implant surface and the buccal bone and (2) onto the buccal bone, overcontouring the buccal bone plate. Two studies\(^{13,22} \) on implants placed immediately postextraction with simultaneous guided bone regeneration procedures reported high percentages of buccal bone loss. These procedures are restricted to filling the gap between the implant and the buccal bone wall, and they do not compensate the latter.\(^{26} \) To date, the main indication for immediate implants is the presence of alveolar integrity, especially of the buccal socket wall, relegating all cases with defects to a deferred or early implant placement, accompanied by a bone and soft tissue regeneration procedure to compensate for the buccal wall defect.\(^{15} \) In the present study, buccal bone presence was seen as a result of the regeneration procedure used, which was similar to that applied in the approach with early implant placement after 4 to 8 weeks of soft tissue healing (type 2).\(^{16,27} \)

As for the buccal bone plate thickness, studies where the gap between the implant and buccal bone was filled with bovine biomaterial report a mean thickness of 2.12 mm 1 year later.\(^{28} \)

In a similar study, the average buccal bone thickness was 0.9 mm, 1.4 mm, and 1.3 mm measured at 2 mm, 4 mm, and 6 mm apical to the implant shoulder, respectively,\(^{29} \) while the average buccal bone thickness in the present study was 3.29 mm, 3.63 mm, and 3.34 mm at the same measurement locations.

At 1 year posttreatment, CBCT evaluations of IS–AC showed that the alveolar ridge peak was generally localized above the implant shoulder in both treatment groups, with higher bone heights observed in the flapless intervention, which is in agreement with other studies.\(^{30} \)

Surface treatment of the implant neck area, such as laser microgrooves, decreases the peri-implant crestal bone loss compared to implants with fully machine-turned or granulated collar segments (without the addition of microthreads).\(^{26,31} \)

Like other studies describing the approach with early implant placement after 4 to 8 weeks of soft tissue healing (type 2), the present study found that using this anorganic bovine bone mineral matrix not only improves volume, but it also provides long-term stability of the regenerated bone wall due to its low replacement rate.\(^{30} \)

Previous studies\(^{15,19} \) demonstrated that using Bio-Oss collagen graft (Geistlich) to fill the buccal gap in a postextraction implant reduced vertical buccal resorption from 1.3 ± 0.7 mm to 0.1 ± 0.5 mm. From previous studies, it appears that the implant position and buccal bone thickness can influence the thickness and height of the buccal bone at the implant.\(^{32,33} \)

ISQ readings during implant placement yielded an average ISQ of 52; an ISQ > 60 is recommended whenever accelerated loading protocols are used.\(^{31} \)

In the present study, ISQ distributions were similar in both groups at the 1-year follow-up, with marked increases in implant stability that were in agreement with previous data.

The present study has several limitations. First, the number of patients per group was low, which would require more clinical cases to enhance the significance of the results. Further, the comparison between CBCT scans taken before surgery and 1 year after implant placement is not entirely adequate, although it was only used to compare the ART. Finally, some considerations were not taken into account in the present study, such as the depth of the horizontal defect from the facial bone wall to the implant surface and its influence on the facial bone wall thickness at the implant site.
Conclusions

Within the limitations of the present study, the results show that buccal bone covering the rough surface of the implant was found in all cases of immediate single implant placement with simultaneous bone augmentation. Hard tissues responded more favorably in the flapless group over an observation period of 1 year.

Acknowledgments

The authors declare no conflicts of interest.

References


## Appendices

### Appendix Table 1 Buccal Bone Thickness According to Root Third, Group, and Stage

<table>
<thead>
<tr>
<th>Root third</th>
<th>Group</th>
<th>Stage</th>
<th>Pretreatment</th>
<th>1-y follow-up</th>
<th>Difference</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical</td>
<td>Flap</td>
<td>Pretreatment</td>
<td>0.84 ± 0.38</td>
<td>2.80 ± 0.63</td>
<td>1.97 ± 0.67</td>
<td>.075</td>
</tr>
<tr>
<td></td>
<td>Flap</td>
<td>1-y follow-up</td>
<td>2.80 ± 0.63</td>
<td>1.97 ± 0.67</td>
<td>0.84 ± 0.38</td>
<td>.075</td>
</tr>
<tr>
<td></td>
<td>No flap</td>
<td>Pretreatment</td>
<td>0.56 ± 0.47</td>
<td>3.29 ± 0.89</td>
<td>2.23 ± 0.97</td>
<td>.075</td>
</tr>
<tr>
<td></td>
<td>No flap</td>
<td>1-y follow-up</td>
<td>3.29 ± 0.89</td>
<td>2.23 ± 0.97</td>
<td>0.56 ± 0.47</td>
<td>.075</td>
</tr>
<tr>
<td>Middle</td>
<td>Flap</td>
<td>Pretreatment</td>
<td>0.69 ± 0.55</td>
<td>2.93 ± 0.32</td>
<td>2.25 ± 0.68</td>
<td>.089</td>
</tr>
<tr>
<td></td>
<td>Flap</td>
<td>1-y follow-up</td>
<td>2.93 ± 0.32</td>
<td>2.25 ± 0.68</td>
<td>0.69 ± 0.55</td>
<td>.089</td>
</tr>
<tr>
<td></td>
<td>No flap</td>
<td>Pretreatment</td>
<td>0.59 ± 0.32</td>
<td>3.63 ± 0.85</td>
<td>3.04 ± 0.85</td>
<td>.089</td>
</tr>
<tr>
<td></td>
<td>No flap</td>
<td>1-y follow-up</td>
<td>3.63 ± 0.85</td>
<td>3.04 ± 0.85</td>
<td>0.59 ± 0.32</td>
<td>.089</td>
</tr>
<tr>
<td>Apical</td>
<td>Flap</td>
<td>Pretreatment</td>
<td>0.65 ± 0.53</td>
<td>3.18 ± 0.34</td>
<td>2.53 ± 0.63</td>
<td>.796</td>
</tr>
<tr>
<td></td>
<td>Flap</td>
<td>1-y follow-up</td>
<td>3.18 ± 0.34</td>
<td>2.53 ± 0.63</td>
<td>0.65 ± 0.53</td>
<td>.796</td>
</tr>
<tr>
<td></td>
<td>No flap</td>
<td>Pretreatment</td>
<td>0.54 ± 0.18</td>
<td>3.34 ± 1.31</td>
<td>2.80 ± 1.34</td>
<td>.796</td>
</tr>
<tr>
<td></td>
<td>No flap</td>
<td>1-y follow-up</td>
<td>3.34 ± 1.31</td>
<td>2.80 ± 1.34</td>
<td>0.54 ± 0.18</td>
<td>.796</td>
</tr>
<tr>
<td>Average</td>
<td>Flap</td>
<td>Pretreatment</td>
<td>0.72 ± 0.47</td>
<td>2.97 ± 0.30</td>
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<td></td>
<td>Flap</td>
<td>1-y follow-up</td>
<td>2.97 ± 0.30</td>
<td>2.25 ± 0.52</td>
<td>0.72 ± 0.47</td>
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<tr>
<td></td>
<td>No flap</td>
<td>Pretreatment</td>
<td>0.56 ± 0.29</td>
<td>3.42 ± 0.99</td>
<td>2.86 ± 0.99</td>
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<tr>
<td></td>
<td>No flap</td>
<td>1-y follow-up</td>
<td>3.42 ± 0.99</td>
<td>2.86 ± 0.99</td>
<td>0.56 ± 0.29</td>
<td>.143</td>
</tr>
</tbody>
</table>

Values are presented in millimeters as mean ± SD.

<sup>a</sup>Mann-Whitney test (bilateral).

### Appendix Table 2 Alveolar Ridge Thickness According to Group and Stage

<table>
<thead>
<tr>
<th>Group</th>
<th>Stage</th>
<th>Pretreatment</th>
<th>1-y follow-up</th>
<th>Difference</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flap</td>
<td>Pretreatment</td>
<td>7.48 ± 0.72</td>
<td>8.32 ± 0.30</td>
<td>0.84 ± 0.53</td>
<td>.063</td>
</tr>
<tr>
<td>No flap</td>
<td>1-y follow-up</td>
<td>8.33 ± 1.39</td>
<td>10.06 ± 1.17</td>
<td>1.73 ± 1.15</td>
<td>.063</td>
</tr>
</tbody>
</table>

Values are presented in millimeters as mean ± SD.

<sup>a</sup>Mann-Whitney test (bilateral).

### Appendix Table 3 Distance from the Implant Shoulder to the Alveolar Crest (IS–AC) According to Group and Stage

<table>
<thead>
<tr>
<th>Group</th>
<th>Stage</th>
<th>Pretreatment</th>
<th>1-y follow-up</th>
<th>Difference</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flap</td>
<td>Pretreatment</td>
<td>−0.33 ± 0.56</td>
<td>0.44 ± 0.50</td>
<td>0.77 ± 0.91</td>
<td>.218</td>
</tr>
<tr>
<td>No flap</td>
<td>1-y follow-up</td>
<td>−0.80 ± 0.82</td>
<td>0.84 ± 0.95</td>
<td>1.64 ± 1.64</td>
<td>.218</td>
</tr>
</tbody>
</table>

Values are presented in millimeters as mean ± SD.

<sup>a</sup>Mann-Whitney test (bilateral).
### Appendix Table 4  Distance from the Implant Shoulder to the First Bone-to-Implant Contact (IS–BIC) According to Group and Stage

<table>
<thead>
<tr>
<th>Group</th>
<th>Stage</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretreatment</td>
<td>1-y follow-up</td>
</tr>
<tr>
<td>Flap</td>
<td>–9.09 ± 1.41</td>
<td>–0.21 ± 0.16</td>
</tr>
<tr>
<td>No flap</td>
<td>–8.25 ± 2.51</td>
<td>–0.56 ± 0.40</td>
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</table>

Values are presented in millimeters as mean ± SD.  
<sup>a</sup>Mann-Whitney test (bilateral).

### Appendix Table 5  Horizontal Defect Depth (HDD) by Group and Stage

<table>
<thead>
<tr>
<th>Group</th>
<th>Stage</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Pretreatment</td>
<td>1-y follow-up</td>
</tr>
<tr>
<td>Flap</td>
<td>2.30 ± 0.67</td>
<td>0.00 ± 0.00</td>
</tr>
<tr>
<td>No flap</td>
<td>3.17 ± 0.97</td>
<td>0.00 ± 0.00</td>
</tr>
</tbody>
</table>

Values are presented in millimeters as mean ± SD.  
<sup>a</sup>Mann-Whitney test (bilateral).

### Appendix Table 6  Implant Stability by Group and Stage

<table>
<thead>
<tr>
<th>Group</th>
<th>Stage</th>
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<tbody>
<tr>
<td></td>
<td>Pretreatment</td>
</tr>
<tr>
<td>Flap</td>
<td>52.7 ± 12.9</td>
</tr>
<tr>
<td>No flap</td>
<td>51.5 ± 14.2</td>
</tr>
<tr>
<td>P&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.796</td>
</tr>
</tbody>
</table>

Values are presented in implant stability quotient values as mean ± SD.  
<sup>a</sup>Mann-Whitney test (bilateral).