Comparison of Peri-implant Soft Tissue Color with the Use of Pink-Neck vs Gray Implants and Abutments Based on Soft Tissue Thickness: A 6-Month Follow-up Study

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Purpose: To compare the optical effects of an immediately placed anodized pink-neck implant and abutment vs a conventional gray implant and abutment in relation to soft tissue thickness 6 months after the restoration was completed. Materials and Methods: Forty patients with a hopeless maxillary anterior tooth received an immediate implant and an immediate provisional or custom healing abutment after flapless extraction. Participants were randomized to receive either a conventional titanium implant (control) or a pink-neck implant (test). All patients then received two identical CAD/CAM titanium abutments (one conventional gray, delivered first, and one anodized to appear pink, delivered 3 weeks after) and a zirconia crown. A spectrophotometer was used to record the color of the peri-implant mucosa and gingiva 3 weeks after delivery of each abutment and 6 months after the final restoration was delivered. The color difference between the two sites was calculated ($\Delta L^*$, $\Delta a^*$, $\Delta b^*$), and correlations with soft tissue thickness, change in ridge dimension, and implant position were assessed. Results: Irrespective of the randomization group, changing the abutments from gray to pink showed a change in color between the peri-implant mucosa and the natural gingiva. Patients with a thin gingival biotype showed a statistically significant color change ($P = .00089$) in the $a^*$ axis, meaning that the gingiva appeared more pink ($\Delta a^*$). No significant correlation between the soft tissue color and buccolingual collapse, vertical recession, or implant position was observed in either group. Conclusion: The difference in color observed between the peri-implant mucosa and the gingiva was considerable in all groups. Anodized pink implants and abutments could reduce the difference in the red aspect ($\Delta a^*$) of the peri-implant mucosa compared to the adjacent gingiva in patients with a thin biotype. Int J Prosthodont 2020; 33:29–38. doi: 10.11607/ijp.6205
A major challenge with implant restorations in the aesthetic zone is to provide patients with a crown and peri-implant mucosa in harmony with the adjacent teeth, restoring both function and esthetics. Although successful integration of immediate implants has been widely reported, soft tissue esthetic outcomes have not been well documented.1,2 Success of single anterior implant treatment is determined not only by high survival rates but by the quality of the long-term survival, which is dictated by a mixture of several factors,3 such as the color of the peri-implant mucosa4 and the soft tissue configuration and shape of the implant site5 being in harmony with the gingiva of the adjacent teeth.6 Studies have reported that the color of the peri-implant mucosa around single-tooth implant crowns did not match the color of the adjacent gingiva in the majority of cases,7 no matter what type of restorative material was selected.8

Spectrophotometry is the method most frequently used to objectively assess color differences in implant dentistry.9 The threshold of \( \Delta E \) for tooth color differences has been determined to be \( \Delta E = 3.7 \).10 The \( \Delta E \) threshold to determine clinical appreciable differences of mucosal color, on the other hand, has been calculated to be in a range from 3.11 to 7.512 to 8.74.13 Gingival tissue biotype as described by Weisgold14 could affect the appearance and color of the peri-implant mucosa. A thick biotype is more frequently observed in the population than a thin biotype.15,16 Thin tissue not only presents a risk for more marked recession,1 but tends to be more translucent, contributing to an undesirable shine-through effect of the underlying material.17 Titanium abutments can cause an esthetic challenge due to their metallic color shining through the mucosa, even when placed subgingivally.12,18,19 When the relationship between gingival translucency and peri-implant mucosa thickness is evaluated, masking effects can be expected when the peri-implant mucosa is thicker than 2.0 mm20 or between 1.5 and 3 mm.4,17,21 However, other studies have reported that tissue thickness did not have an effect on the \( \Delta E \) values at the peri-implant soft tissue level.8,18,22 Regarding restorative materials, some studies favor zirconia as the best abutment material for providing a closer match of the peri-implant mucosa to the adjacent gingiva.8,18 However, other studies have reported that neither metal nor zirconia were optimal choices, as both produced discoloration of the gingiva4,23,24—possibly because the color of zirconia is too white compared to natural teeth.25

Soft tissue volume can also affect the esthetic result. Maintaining the alveolar ridge labial convexity after an immediate implant is challenging even following proper surgical techniques.26 The horizontal collapse observed after immediate implant placement has been reported to be as high as 80%.27 Several solutions to clinically improve the discoloration of the peri-implant mucosa have been suggested, such as improving the optical properties of the restorative material, thickening the covering mucosa,12 and altering the color of the implant neck to a light pink.28

The authors conducted a study with the primary objective of evaluating the optical effects of the pink-neck implant and abutment system. The results pertaining to the primary objective showed that when a pink abutment was used, there was a significant color change of the peri-implant mucosa above the detectable color threshold.29 When comparing the peri-implant mucosa to the adjacent gingiva, it was observed that the color difference in the red aspect was minimized when using a pink implant and abutment.30 The present article shows the results of the secondary objective of this prospective randomized controlled clinical study, which was to evaluate the optical effects of an immediately placed anodized pink-neck implant and abutment in relation to soft tissue thickness, implant position, and change in ridge dimension for an evaluation period of 6 months following prosthesis delivery.

MATERIALS AND METHODS

Patient Selection, Study Population, and Design

This multicenter, randomized, controlled clinical trial study was approved by the institutional review boards of Harvard Medical School/Harvard School of Dental Medicine and Columbia University. A total of 40 patients 18 years or older who met the study inclusion criteria were recruited through the Harvard Dental Center faculty and teaching practices and the Columbia University College of Dental Medicine periodontics, prosthodontics, and implant dentistry clinics.

Patients with a single maxillary anterior hopeless (but periodontally sound) tooth (second premolar to second premolar) in need of extraction due to caries, fracture, or poor endodontic prognosis were selected. Only patients with probing depths of 3 mm or less were considered for the study. All patients had to have a healthy contralateral and/or adjacent tooth. Exclusion criteria included any systemic condition preventing implant placement or any other surgical procedure; female subjects who were pregnant, lactating, or who intended to become pregnant during the study period; presence of acute infectious lesions in the surgical area; history of smoking within the last 6 months; unfavorable occlusal schemes for immediate loading; and/or presence of iatrogenic pigmnetations of the gingiva on the study site.

Of the 52 patients screened, 40 were enrolled in the study (20 patients in each study center). After obtaining a proper consent for the study, subjects were enrolled and randomized into two groups: a control group...
that received a conventional gray implant (PrimaConnex, Keystone Dental) and a conventional custom-made gray titanium abutment as the final restoration, and a test group that received a pink-neck anodized implant (Genesis, Keystone Dental) and a pink anodized custom abutment as the final restoration. Randomization envelopes were prepared by the investigators and opened on the day of surgery.

The two implants present the same restorative connection that allows for platform switching; however, the thread design on the pink-neck anodized implant is more aggressive in the apical portion and less marked on the coronal aspect of the implant. Both implants present a threadless surface on the coronal aspect, with the conventional gray implant being wider (Fig 1).

**Surgical Procedure**

All patients were premedicated with either 2 g of amoxicillin or 600 mg of clindamycin 1 hour prior to surgery. Hopeless teeth were extracted with a flapless approach, and evaluation of the socket walls was done to confirm that the buccal plate was intact. If the site was not ideal for immediate implant placement due to a compromised buccal plate, a delayed implant placement was planned, and required grafting procedures were completed. These patients were not included in the study.

Implants were placed following the manufacturer’s instructions based on the randomization. The implant platform was placed 3 to 4 mm apically from the cementoenamel junction of the adjacent teeth to allow for adequate space to develop the subgingival contours. Implants were placed by titrating the insertion torque values in increments of 5 N/cm to determine the final torque at placement. No bone graft material was used to fill gaps between the implant and the tooth socket. Subjects were given postsurgical instructions and medications including antibiotics (amoxicillin 500 mg or clindamycin 300 mg) and analgesics (ibuprofen 600 to 800 mg).

**Prosthetic Procedure**

Implants placed with an insertion torque of 25 N/cm or more were restored with an immediate full-contour screw-retained provisional made of autopolymerized polymethyl methacrylate (Super T, American Consolidated) placed without occlusal contact. When the insertion torque of the implants was less than 25 N/cm, a customized healing abutment was fabricated with autopolymerized polymethyl methacrylate (Super T) to maintain the soft tissue contour along with an Essix appliance or a provisional bonded fixed prosthesis.

Final impressions were made 3 months after implant placement with an open-tray impression post (Keystone Dental), disposable stock plastic trays (Disposable Trays, GC America), and polyether impression material (Impregum 3M, ESPE). To record the exact dimensions of the soft tissues, the contour of the provisional restorations was copied with polyvinylsiloxane material (Blu-Mousse, Parkell), and the replicated contour was transferred to the impression coping using autopolymerized polymethyl methacrylate (Super T).

Two identical computer-aided design/computer-assisted manufactured (CAD/CAM) titanium custom abutments were fabricated for each patient using the same titanium alloy, one in conventional gray and one anodized to appear pink in color (Keystone Dental) (Fig 2). All patients were first restored with the gray abutment and a zirconia cement-retained crown (Katana Noritake, Cusp) cemented with temporary cement (TempBond NE, Kerr Dental). Three weeks after, the gray abutment was replaced by an identical pink abutment, and the same zirconia crown was recemented with temporary cement (TempBond). For patients randomized into the control group, the pink abutment was replaced by the gray abutment 3 weeks after insertion of the pink abutment, so that the gray abutment was the final restoration for the control group and the test group remained with the pink abutment. Measurements for the 6-month follow-up appointment were therefore completed 7 months after insertion for the test group and 6 months after insertion for the control group (since the pink implant abutment had already been in the patient’s mouth for a month in the test group).

**Clinical Measurements**

The following variables were measured though the duration of the study.

**Color Measurements.** A dental spectrophotometer (Crystaleye, Olympus) was used by an experienced researcher at each study center to capture spectral images of the peri-implant mucosa and the adjacent or
Vertical Implant Position. The vertical distance of the implant to the free gingival margin was measured using a probe (15 UNC Color-Coded Probe, Hu-Friedy).

Radiographic Measurements
All patients had a cone beam computed tomography (CBCT) (i-CAT Next Generation, Imaging Sciences International) scan of the maxillary arch taken prior to enrollment with an image resolution of 0.3 mm to evaluate the presence of an intact buccal plate of the study tooth. A second CBCT was done 6 months after delivery of the final crown. Measurements of the buccolingual dimensions of the ridge on the site of the tooth to be extracted and with the implant placed were recorded on a sagittal section. To ensure that the measurements were done at the same site and spatial position on both CBCT scans, software (InVivo 5, Anatomage) was used to orient the scans and analyze the sagittal sections for measurements (Fig 4).

Cast Analysis. Alginate impressions (Jeltrate Fast Set, Dentsply Sirona) were made at baseline, crown delivery, and 6 months later at the follow-up visit. The impressions were poured in type III gypsum (Microstone, Whip Mix). A digital scanner (Romexis, Planmeca) was used to digitally scan all casts made at baseline, delivery, and the 6-month follow-up.

A digital comparison software (Compare, Planmeca) was used to superimpose the casts. Each baseline cast was digitally trimmed at the lingual aspect to create a reference line. The casts were sliced at the midbuccal sections of the test site, and three-dimensional sagittal sections were obtained. A protractor was aligned with the vertical reference line on the baseline cast, and the horizontal portion of the protractor was used to draw a line from the baseline cast to the delivery and 6-month casts. Using the software, 1-mm incremental lines were drawn, and the difference in the horizontal and vertical contours was measured (Fig 5).

contralateral healthy gingiva at different observation times. The first measurement was done 3 weeks after delivery of the gray abutment and zirconia crown. For patients in the control group, these values were named as gray-gray (GG), and for patients in the test group, as pink-gray (PG). The second measurement was done 3 weeks after the abutments were switched to the pink abutment, and the values were named for patients in the control group as gray-pink (GP) and patients in the test group as pink-pink (PP). The last measurements were done at the 6-month follow-up appointment.

Tissue Biotype. Tissue biotype was determined to be thin if the probe was visible through the soft tissue and thick if the probe was not visible when probing the midbuccal aspect of the tooth to be extracted (15 UNC Color-Coded Probe, Hu-Friedy). This measurement was repeated at the 6-month follow-up appointment.

Horizontal Implant Position. The distance from the most buccal aspect of the implant to the internal buccal aspect of the socket wall was measured using a periodontal probe (15 UNC Color-Coded Probe, Hu-Friedy) (Fig 3).
Data Analyses

Summary statistics (mean, standard deviation, and range) were calculated for all variables. Distribution of thick vs thin biotype within the groups was analyzed using Fisher exact test. One-way analysis of variance (ANOVA) was used to determine the differences in variables between groups (control and test) divided by tissue biotype. To assess the correlation between values, Pearson correlation test was used. The difference in color between the peri-implant mucosa and the adjacent gingiva was analyzed, stratified by tissue biotype and randomization group between each of the abutments with paired Student t tests. Values were considered statistically significant at P < .05.

Color Analysis

From the spectral images captured, the color data (CIELAB color coordinates; L*, a*, b*) in three incremental areas of 1 × 1 mm from the gingival margin in the apical direction were obtained. These areas were named cervical (C), middle (M), and apical (A) (Fig 6). Triple color measurement was performed, and the mean of these measurements was used for data analysis and statistics. Using the CIELAB color coordinates L* (lightness), a* (green-red axis), and b* (blue-yellow axis), the color difference DE was determined using the following equation: \( \Delta E = (\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2 \) (Fig 7). The data were stratified by implant type and tissue biotype.
shown is divided into the different aspects of color (ie, $\Delta L^*$, $\Delta a^*$, $\Delta b^*$, $\Delta E$) and into four different groups based on randomization and tissue biotype. Only 33 patients were evaluated for color difference at the 6-month follow-up, since 7 patients were lost. One-way ANOVA showed no statistically significant difference between the mean color values of all areas measured per group.

Table 3 summarizes the combined means of additional variables: the mean values in buccolingual collapse and recession observed in the casts, buccal bone thickness measured on the CBCT scan, and horizontal and vertical implant positions per randomization group and tissue biotype. According to one-way ANOVA, no statistically significant difference was observed in the values of buccolingual collapse, recession, implant position, or buccal plate thickness between groups. The difference in the number of patients observed with the different variables is due to limitations on patient compliance at the 6-month recall appointments. Three patients in the test group and four patients in the control group were not able to come to the required follow-up appointment for personal reasons.

The differences in color between the peri-implant mucosa and adjacent gingiva with the different abutments (gray or pink), stratified according to tissue biotype, are presented in Table 4. The color difference was further analyzed and divided by group (Table 5). The analysis was first done divided by tissue biotype irrespective of the study group due to the limited number of observations, specifically in patients randomized to the control group with thin gingival biotype (n = 3).

In general, the difference in color between the peri-implant mucosa and the gingiva of the adjacent teeth became smaller once the gray abutment was replaced by the pink abutment. However, in the control group with thin biotype as well as in the test group with thick biotype, an increase was observed in the $\Delta b^*$ aspect of color (Table 4). The difference in color, analyzed

### Table 1

<table>
<thead>
<tr>
<th>Tissue Biotype</th>
<th>Total no. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin</td>
<td>Thick</td>
</tr>
<tr>
<td>Pink</td>
<td>6</td>
</tr>
<tr>
<td>Gray</td>
<td>3</td>
</tr>
</tbody>
</table>

$P = .4315$.

### Table 2

<table>
<thead>
<tr>
<th>No. of patients</th>
<th>$\Delta a^*$</th>
<th>$\Delta b^*$</th>
<th>$\Delta L^*$</th>
<th>$\Delta E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pink, thick</td>
<td>11</td>
<td>0.27</td>
<td>3.10</td>
<td>4.97</td>
</tr>
<tr>
<td>Pink, thin</td>
<td>6</td>
<td>1.44</td>
<td>3.17</td>
<td>3.87</td>
</tr>
<tr>
<td>Gray, thick</td>
<td>14</td>
<td>2.33</td>
<td>3.36</td>
<td>4.48</td>
</tr>
<tr>
<td>Gray, thin</td>
<td>2</td>
<td>1.52</td>
<td>2.32</td>
<td>5.09</td>
</tr>
</tbody>
</table>

One-way ANOVA.

### RESULTS

The patient population included 20 men and 20 women aged 24 to 72 years with a mean age of 46.9 (± 3.2) years. The treatment sites included 13 central incisors, 11 lateral incisors, 4 canines, and 12 premolars. Twenty patients were randomized to the test group (Genesis implant and pink abutment), and 20 patients were randomized to the control group (PrimaConnex implant and gray abutment).

Table 1 shows the tissue biotype distribution by group.

The mean color differences between the peri-implant mucosa and gingiva of the adjacent or contralateral tooth per group are shown in Table 2. The average...
with paired Student t test, was statistically significant in several instances. Irrespective of group, patients with a thin biotype showed a statistically significant reduction in color difference, specifically in the Δa* aspect of color (P = .00089). When analyzing by group, patients with a thin biotype in both groups had a significantly reduced difference in color in the Δa* aspect of the gingiva when changing the abutment from gray to pink (P = .003 and P = .02 respectively), which means that the gingiva appeared more pink (Δa*). No statistically significant difference in color was observed in patients with a thick biotype for either group.

The implant position also had an effect on the difference in the color of the soft tissues; however, this difference was only observed with the horizontal implant position. There were no significant correlations between vertical implant position in either group. Patients randomized to pink implants showed no correlation between the implant position (vertical and horizontal) and difference in color of the soft tissue. However, patients randomized to gray implants showed a statistically significant positive correlation in the ΔL* aspect of color (r = 0.48, P = .05 for ΔL cervical; and r = 0.59, P = .01 for ΔL middle). This means that the greater the distance between the implant and the buccal plate, the greater the difference seen in the lightness/darkness aspect of soft tissue (Fig 8).

When evaluating buccolingual collapse and vertical recession measured in the casts at the 6-month follow-up, there was no significant correlation with the tissue color with either the test or control groups. The collapse and recession values seen in both groups were similar. The collapse observed in the CBCT scans 6 months after delivery of the final restoration did not show any significant correlation with the color.

**DISCUSSION**

The color of the peri-implant mucosa contributes substantially to a successful long-term esthetic result.4 The use of a spectrophotometer in the present study ensured that the color of the gingiva was quantitatively measured in an objective manner. The difference in color observed between the peri-implant mucosa and the gingiva was considerable in all groups. This result is in agreement with the findings of Fürhauser et al,7 and Bresan et al,8 demonstrating that matching the color of the peri-implant mucosa to the gingiva is a very challenging aspect of implant esthetics.

One possible explanation for the difference in color of the peri-implant mucosa could be attributed to morphologic differences between the peri-implant mucosa and the gingiva around the teeth. One major difference is that the peri-implant mucosa contains a smaller amount of blood vessels compared to the gingiva.31 Kleinheinz et al determined that the red coloration of the soft tissue depends on the degree of keratinization and on the distribution and number of blood vessels, showing a relation between vascularization and gingival color.32

A difference in color of the peri-implant mucosa and that of the adjacent gingiva was observed in all patients irrespective of group. However, the difference observed

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**Table 3a** Mean and Standard Deviation Recession (mm) 6 Months After Crown Delivery.

<table>
<thead>
<tr>
<th>Recession</th>
<th>Pink, thin</th>
<th>Pink, thick</th>
<th>Gray, thin</th>
<th>Gray, thick</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.37</td>
<td>1.28</td>
<td>1.99</td>
<td>1.13</td>
<td>.60</td>
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<tr>
<td>Standard deviation</td>
<td>1.05</td>
<td>0.79</td>
<td>0.42</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>3</td>
<td>11</td>
<td>2</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3b** Mean and Standard Deviation Buccolingual Collapse (mm) 6 Months After Crown Delivery Measured at Different Distances from the Free Gingival Margin

| Collapse at 0 mm | 0.44 | 0.11 | 0.6 | 0.94 | .31|
| Collapse at 1 mm | 0.46 | 0.87 | 0.86 | 0.68 | .64|
| Collapse at 2 mm | 0.55 | 0.70 | 0.98 | 0.68 | .85|
| Collapse at 3 mm | 0.56 | 0.53 | 0.97 | 0.68 | .80|
| Collapse at 4 mm | 0.52 | 0.41 | 0.84 | 0.7 | .69|
| Collapse at 5 mm | 0.52 | 0.34 | 0.51 | 0.55 | .85|

**Table 3c** Mean and Standard Deviation Buccal Plate Thickness and Horizontal and Vertical Implant Positions (mm)

| Buccal bone thickness 3 mm below crest | Pink, thin | 0.72 (1.51) | Pink, thick | 1.19 (0.96) | Gray, thin | 0.99 (1.39) | Gray, thick | 1.25 (0.87) | P value | .76|
| Horizontal implant position | 1 | 2.6 (1.27) | 2.17 (1.44) | 2.39 (1.24) | .07|
| Vertical implant position | 3.67 (0.82) | 3.9 (1.18) | 5 (1.73) | 4.28 (0.71) | .21|

One-way ANOVA.
in patients with thin biotype with the use of a pink abutment was significantly lower in the $a^*$ aspect of color ($P = .003$ for the test group and $P = .02$ for the control group). This means that in patients with thin biotype, the mucosa with a gray abutment looked significantly less red than the gingiva of the contralateral or adjacent tooth. This statistically significant difference was observed in all analyses completed for thin biotype patients when analyzed as one group or by study group.

A thick soft tissue biotype is a desirable characteristic that will positively affect the esthetic outcome of an implant-supported restoration. Thick soft tissue presents the advantage of being more resistant to mechanical and surgical insults, less susceptible to mucosal recession, and having more tissue volume for prosthetic manipulation. In a thick biotype environment, immediate placement of an implant can therefore be completed with more predictable results. In thin biotype cases, there is a possibility of significant resorption, which may cause a high impact on esthetics. Benic et al concluded that the discoloration of peri-implant mucosa can be clinically addressed by improving the optical properties of the restorative material and by thickening the covering mucosa. Based on the results of the present study, a possible alternative for thin biotype patients could be the use of a pink-neck implant and pink abutments to improve the color appearance of the peri-implant mucosa.

In this study, the color of the peri-implant mucosa was not affected by the buccolingual collapse of the tissue. This result is most likely because the collapse observed was similar between groups, making tissue thickness more significant for the color of the soft tissue. It is important to note that the maximum collapse observed was 1 mm and no bone graft was placed in the gap between the implant and the buccal bone plate.
Evaluating implant position, a positive correlation was seen in patients randomized to gray implants between the $\Delta L^*$ aspect of color and the horizontal implant position. This means that the greater the distance between the implant and the buccal plate, the greater the difference seen in the lightness/darkness aspect of the soft tissue. An explanation for this observation is that an increased collapse can occur if the implant is placed with a bigger gap from the buccal bone plate. This observation is against general intuition; however, a difference could have been observed if a bone graft material was placed in the gap, or it can vary depending on the buccal plate thickness.

This study had several methodologic limitations. The study population consisted of 22% of patients with a thin tissue biotype, which is closer to the 15% seen in the general population. However, the total number of patients with thin biotype for the control group presented a very low number of observations. A larger number of patients may be needed to demonstrate a clear correlation between soft tissue thickness and peri-implant mucosa color. Additional studies with potentially larger sample sizes are necessary to test each of these factors to determine which aspects have the most effect on the color of the peri-implant mucosa with different colored abutments and implants.

In addition, due to the protocol design, no bone graft material was placed in the gap between the implant and the buccal bone. This could be considered a weakness, since there are some reports in the literature that show that placing a bone graft on immediately placed implants can result in less soft tissue changes over time. Also, color measurements were not completed in the same amount of time for both groups for the 6-month follow-up appointment. The gray abutment and crown were delivered for the control group after all of the pink abutment measurements. Therefore, the follow-up appointment for the control group was completed at 6 months, but for the test group, the measurements were done 7 months after insertion, since the crown had already been in the patient’s mouth for a month. It is hypothesized that the 1-month difference between the groups did not change the results drastically, but should be acknowledged as a limitation of the study design.

CONCLUSIONS

The difference in color observed between the peri-implant mucosa and the gingiva was considerable in all groups. Anodized pink implants and abutments could reduce the difference in the red aspect ($\Delta a$) of the peri-implant mucosa compared to the adjacent gingiva in patients with a thin gingival biotype. A larger sample size may be necessary to determine the correlations of other variables, such as the soft tissue collapse (buccolingual), the implant position, and the color difference on the color of the peri-implant mucosa.

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Effects of Occlusal Forces on the Peri-implant–Bone Interface Stability

Occlusal forces and their influence on the initiation of peri-implant bone loss, as well as their relationship with peri-implantitis, have created discussion during the past 30 years given the discrepancies observed in clinical, animal, and finite element analysis studies. Beyond these contradictions, in the case of an osseointegrated implant, occlusal forces can influence the implant-bone interface and the cells responsible for bone remodeling in different ways that may result in the maintenance or the loss of the osseointegration. This comprehensive review focuses on the information available about the forces transmitted through the implant-crown system to the implant-bone interface and the mechano-transduction phenomena responsible for the bone cells’ behavior and their interactions. Knowledge of the basic molecular biology of peri-implant bone would help clinicians understand the complex phenomenon of occlusal forces and their effects on the implant-bone interface and would allow better control of the negative effects of mechanical stresses, leading to therapy with fewer risks and complications.