Clinical and Radiographic Evaluation of the Papilla Level Adjacent to Single-Tooth Dental Implants. A Retrospective Study in the Maxillary Anterior Region

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Background: The regeneration of gingival papillae after single-implant treatment is an area of current investigation. This study was designed to determine: 1) whether the distance from the base of the contact point to the crest of the bone would correlate with the presence or absence of interproximal papillae adjacent to single-tooth implants, and 2) whether the surgical technique at uncovering influences the outcome.

Methods: A clinical and radiographic retrospective evaluation of the papilla level around single dental implants and their adjacent teeth was performed in the anterior maxilla in 26 patients restored with 27 implants. Six months after insertion, 17 implants were uncovered with a standard technique, while 10 implants were uncovered with a technique designed to generate papilla-like formation around dental implants. Fifty-two papillae were available for clinical and radiographic evaluation. The presence or absence of papillae was determined, and the effects of the following variables were analyzed: the influence of the 2 surgical techniques; the vertical relation between the papilla height and the crest of bone between the implant and adjacent teeth; the vertical relation between the papilla level and the contact point between the crowns of the teeth and the implant; and the distance from the contact point to the crest of bone.

Results: When the measurement from the contact point to the crest of bone was 5 mm or less, the papilla was present almost 100% of the time. When the distance was ≥6 mm, the papilla was present 50% of the time or less. The mean distance between the crest of bone and the most coronal papilla level (interproximal soft tissue height) was 3.85 mm (SD = 1.04). When comparing the conventional and modified surgical technique, the relation shifted from 3.77 mm (SD = 1.01) to 4.01 mm (SD = 1.10), respectively.

Conclusions: These results clearly show the influence of the bone crest on the presence or absence of papillae between implants and adjacent teeth. The data also show a positive influence for the modified surgical technique, aimed at reconstructing papillae at the implant uncovering. J Periodontol 2001;72:1364-1371.

KEY WORDS
Dental papilla/anatomy and physiology; dental implants, single tooth; oral surgery/methods.

Long-term efficiency of screw-retained dental implants *ad modum* Brånemark has been clearly demonstrated in cases of complete edentulism1–3 and partial edentulism.4–7 The high success rate has allowed the application of osseointegration principles to be extended to single-tooth edentulism, with similar success regarding the survival rate and marginal bone stability, as observed in complete and partial edentulism.8–18

One of the major problems encountered after tooth extraction is the hard and soft tissue loss.19 Nowadays, the increased esthetic and functional demand20 aims to establish a soft tissue contour with an intact papilla and a gingival outline that is harmonious with the gingival silhouette of the adjacent healthy dentition. Therefore, different management of the soft tissue around the single-tooth restoration to achieve an esthetic result has been proposed as: 1) promotion of the soft tissue between stage 1 and stage 2 with healing abutments21 or soft tissue grafting,22 or 2) creation of a papilla22–24 at stage 2 surgery using periodontal plastic techniques.

Despite the surgical techniques developed, the regeneration of the papilla adjacent to dental implants
is still a matter of debate. Some authors have demonstrated the benefits of surgical management in increasing the surrounding hard and soft tissue; others have discussed the importance of flap design in minimizing possible mid-buccal recession; while others have advocated a possible spontaneous regeneration of the papilla. Therefore, creating predictable papilla reconstruction around the single-tooth implant remains a complex challenge.

Because the single-tooth implant is located close to a natural tooth, it remains difficult to delineate the peri-implant mucosa, gingiva, and the mutual influence on the achievement of a peri-implant papilla. As observed on natural teeth, the biologic width explains part of the soft tissue height, and this seems to be encountered around implants as well. Moreover, around teeth, a close relationship between the distance from the contact point to the alveolar bone level has explained the presence or absence of interdental papilla. In 1997, a classification of papilla restoration around single-tooth implants was proposed. It describes the soft tissue, but does not explain the influence of the different anatomical, surgical, and prosthetic components of the single-tooth implant restoration. The purpose of this study was to characterize the bone level and papilla height in relation to the contact point adjacent to single-tooth, implant-supported restorations. The results were also compared to determine whether a new surgical technique recently described had any influence on the papilla height compared to conventional exposure techniques.

**MATERIALS AND METHODS**

We recalled patients treated with single implants from the Department of Implant Dentistry at Erasme Hospital (Brussels, Belgium). All patients who had been wearing a single-tooth restoration for at least 6 months on osseointegrated dental implants qualified for participation in the study. Fifty-four patients had been treated with single implants; from this list, 26 agreed to participate in the study.

Clinical evaluations were done at 3 buccal sites and 3 palatal sites: 1) probing depth, performed using a periodontal probe with standardized markings; 2) modified bleeding index; 3) presence/absence of plaque; 4) gingival recession; and 5) presence/absence of mucosa. These parameters were used as evaluation criteria. If the soft tissue was inflamed with increased probing depth and plaque accumulation, the patient was regarded as "inflamed" that day and rejected, unless they could pass a second examination. They were then reinstructed on proper oral hygiene and reexamined during another session. These precautions were set to avoid any interpretation of pseudopocketing due to inflammation. Implants placed in the mandible were also rejected from the study because they were considered to be in a non-esthetic region of the mouth.

Of the 54 patients examined, 26 (48.15%) presented minimal plaque accumulation and soft tissue inflammation and were analyzed for the study.

**Patient Characteristics**

In this cross-sectional clinical study, 26 patients (18 women, 8 men; mean age, 43 years; range, 21 to 68 years) received 27 maxillary dental implants in the Department of Oral and Maxillo-Facial Surgery at the Erasme Hospital (Université Libre de Bruxelles). Two patients were smokers (up to 20 cigarettes/day). The surgery was performed by 2 experienced oral and maxillofacial surgeons (CM and PD) under local anesthesia, following the protocol recommended for these implants. Twelve implants were localized in the maxillary incisal region, 6 replaced the lateral incisor, and 3 were located in the canine region. Two implants replaced the first premolars; 4 replaced the second premolar.

All the implants were 13 or 15 mm in length. Twenty-six implants had a diameter of 3.75 mm. One implant replacing a lateral incisor had a diameter of 3.3 mm. After 6 months, second-stage surgery was performed by an experienced periodontist (PA), following 2 techniques: 1) the first technique, "conventional," was described by Adell et al., Lekholm and Jemt, and Odman and uncovers the implant by using a crestal incision with small releasing incisions; 2) the second technique, "modified," was described by Adriaenssens et al., and augments the soft tissue volume to generate interdental papillae. No punch technique was applied. Seventeen implants were treated by the conventional technique, 10 implants by the modified technique. Different abutments were selected, from standard abutments (N = 14) to anatomic abutments customized by the laboratory (1 titanium abutment, 1 ceramic abutment**); some were the more recent computer-individualized abutments (N = 11). The prosthetic treatment was performed at the Department of Implant Dentistry, Erasme Hospital. The mean time since crown insertion was 35 months (6 to 75 months).

The evaluation of papillae was made through a clinical and photographic examination. The presence or absence of the interproximal papilla was determined visually prior to probing and with a photographic slide taken perpendicularly to the buccal surface of the single-tooth restoration crown. The index used was described by Jemt and defined briefly as score 0.
no papilla is present (Fig. 1); score 1, less than half of the papilla is present; score 2, at least half of the papilla is present, but not all the way up to the contact point between the teeth; score 3, the papilla fills up the entire proximal space and is in good harmony with the adjacent papillae (Fig. 2); score 4, the papilla is hyperplastic and covers too much of the single-implant restoration and/or the adjacent tooth. The papilla evaluation was done by 2 blinded investigators (VC and MH) based upon the clinical readings and the slides.

**Radiographic Data**

Retroalveolar radiographs‡‡ were taken using the long-cone paralleling and standardized method. The radiographs were not plicatured to avoid deformation. The x-ray generator was set at 15 mA, 70 Kvp. The evaluation was done immediately after exposure. The radiographs were then digitized, using a dedicated scanner§§ with a resolution of 2,048 per 3,072 lines. Data were analyzed by a computer. The computerized data were then written on a CD-ROM.†† The images were treated using software## to perform the measurements. No modification was done to the pictures. Measurements were done by an operator trained to read implant radiographs (VC). The zero value was set at the fixture abutment junction (FAJ). Measurements were expressed as pixels and then converted to mm with the known value of the shoulder of the implant.

**Measures Principle**

**Calibration.** A reference line had to be set to determine the remaining measures. Because it is a known diameter, the implant abutment joint was selected. A correction factor was therefore calculated between the radiographic measure and the known value. All radiographs were corrected along this principle to calibrate the readings between the series of radiographs.

**Measurement**

The reference unit was the papilla. Therefore, the mesial or distal location was not taken into account. The following distances presented in Figure 3 were measured to the nearest 0.01 mm:

1. The horizontal measure of the width of the implant shoulder at the fixture abutment junction (FAJ) to serve as a calibration tool and a parallel reference line to relate the other vertical measures.
2. The vertical distance between the shoulder of the implant and the most coronal point of the bone level contacting the implant (a).
3. The vertical distance between the shoulder of the implant and the most coronal point of the bone level facing the teeth (b).
4. The vertical distance between the shoulder of the implant and the most coronal papilla level (c).
5. The vertical distance between the shoulder of the implant and the most apical level of the contact point between the crown of the teeth and the implant (d).
6. The vertical distance between the crest of bone and the contact point (e) = (d-b).

From the 27 examined implants, 52 papillae were available for examination. Due to incorrect positioning of the intraoral radiograph or failure to show the entire area, 2 of the 54 papillae could not be studied. All measurements were made by 2 authors (CV and MH).

‡‡ Kodak Ektaspeed, Eastman Kodak Co., Rochester, NY.
§§ Kodak 6000 in raw.
†† Kodak PC Datamanager 5 200.
¶¶ Kodak Photo CD.
## Photoshop, Adobe, San Jose, CA.
In 10 implants (20 papillae), a second set of measurements was performed randomly to evaluate the intra-observer variability. The mean difference between the first and second assessment was negligible. Because this study is cross-sectional and based on descriptive criteria with multiple parameters, statistical analysis was not performed due to the small sample size of the different parameters.

RESULTS
Table 1 shows the clinical distribution of the papilla level between the surgical technique and scoring method. The data show that index scores of 3 with a perfect 100% of papilla fill were achieved only in 57.7% of the papillae studied. The modified technique achieved a better score of 68.5% compared to 51.5% for the conventional technique.

After the radiographic calculation, the mean distance between the FAJ and the most coronal bone contact level (a) was \(-1.76\) mm (SD = 0.75). The maximum papilla level was obtained when the marginal bone level at teeth was a mean distance of 5.13 mm (SD = 0.92) coronal to the FAJ (b) and when the coronal bone contact level facing the implant was \(-1.64\) mm (± 0.30) to the FAJ.

To ensure correct soft tissue adaptation around the implant and avoid pseudo-pocket formation with the modified technique, the relationship between PD and papilla level was analyzed in Table 2. The PD facing the implant was slightly greater than the PD facing the natural tooth, with up to 7 mm encountered at the implant, while only 4.5 mm was seen at the natural tooth. However, a slight difference could be observed with the modified technique compared to the conventional technique. These results clearly show that PD is neither increased at the implant level nor at the teeth after surgery to increase the soft tissue level. While analyzing the data of the soft tissue height in relation to the distance between the bone crest and contact point (Table 3), the overall results, without disclosing the surgical technique, show a soft tissue height of 3.85 mm for the papilla. When disclosing the surgical technique, the straight-line relation remains. For the conventional technique, a soft tissue thickness of ± 3.77 mm was observed, while the modified technique achieved a thickness of ± 4.01 mm. A discrepancy between the missing space to fill (distance bone crest/contact point–soft tissue width) was only 1.47 mm for the modified technique versus 2.98 mm for the conventional technique.

Table 4 shows the papilla level in relation to the interproximal bone crest to the contact point. The results demonstrated that the majority of areas examined were between 4 to 7 mm in distance between the contact point to the bone crest. When the distance from the base of the contact point to the bone crest

![Figure 3. Schematic drawing showing the selected reference points (FAJ) and measured distances (a-d).](image)

Table 1.
Distribution of Papilla Presence or Absence According to Surgery Technique: Index Score Evaluation*

<table>
<thead>
<tr>
<th>Index Score</th>
<th>Total†</th>
<th>Conventional</th>
<th>Modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>4 (7.7)</td>
<td>4 (12)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>1</td>
<td>2 (3.8)</td>
<td>1 (3.0)</td>
<td>1 (5)</td>
</tr>
<tr>
<td>2</td>
<td>16 (30.8)</td>
<td>11 (33.5)</td>
<td>5 (26.5)</td>
</tr>
<tr>
<td>3</td>
<td>30 (57.7)</td>
<td>17 (51.5)</td>
<td>13 (68.5)</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Jemt.27
† Number of papillae observed (%).
Dental Implants and Interproximal Papillae

was 3 to 4 mm, the papilla was fully present or almost fully present (Jemt Index 2 and 3); between 5 to 6 mm, a clear shift seemed to occur with missing papillae (Jemt Index 0 and 1) 50% of the time. Moreover, with the Jemt index score, we could see that the space was not always completely filled (score 3), regardless of the distance.

Table 5 shows the relationship between the mean distance of the contact point to the bone crest and the mean soft tissue height in relation to the Jemt index score.27 The data confirm a clear shift of the presence or absence of papillae between 5 to 6 mm. Moreover, the soft tissue height is at a maximum of 4.00 mm (score 2) with the conventional technique, and 4.40 mm (score 3) with the modified technique.

DISCUSSION

The papillae analyzed in the present study presented bleeding on probing and probing depth comparable with other studies. It is still a matter of debate on how to interpret the inflammatory signs around implants.40 The papillae included in this study did not present any signs or symptoms of inflammation; therefore, misinterpretation of increased papilla volume due to inflammation was avoided.

The interpretation of clinical papillae is a difficult task since many different clinical situations can be encountered while studying single-tooth restorations: from normal gingiva to a denuded root without any papillae. It explains why, in this present study of 54 recall patients, few implants remained (27 implants in 26 patients) to be analyzed when it was necessary to disclose between inflamed gingiva and pathologic conditions. Moreover, many patients, once they were rejected after the first examination and received corrective prophylactic instructions, did not present for a second examination.

A major criticism of the present study is that the analysis was done on a vertical level and did not take into account the horizontal inter-restoration distance as done in other studies.10,41 The single-tooth restoration is a specific entity; the mesio-distal width is never standardized from case to case, and even the distance between the mesial or distal side of one implant is never the same. Therefore, the present study analyzed the papilla as a unit and focused on the relationship between the adjacent teeth and the implant in a vertical dimension. In addition, interpretation of

Table 2.

Probing Depth at Natural Adjacent Teeth and Single-Tooth Implants (mm ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Overall (52)</th>
<th>Conventional (33)</th>
<th>Modified (19)</th>
</tr>
</thead>
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<tr>
<td>Teeth</td>
<td>2.40 ± 0.84</td>
<td>2.50 ± 0.81</td>
<td>2.23 ± 0.87</td>
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<tr>
<td>Implants</td>
<td>3.65 ± 1.26</td>
<td>3.69 ± 1.32</td>
<td>3.57 ± 1.16</td>
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</tbody>
</table>

Table 3.

Soft Tissue Height in Relation to Distance Between Bone Crest and Contact Point (mm ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Overall (52)</th>
<th>Conventional (33)</th>
<th>Modified (19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft tissue height</td>
<td>3.85 ± 1.04</td>
<td>3.77 ± 1.01</td>
<td>4.01 ± 1.10</td>
</tr>
<tr>
<td>Distance contact point to bone crest</td>
<td>6.29 ± 2.25</td>
<td>6.75 ± 2.55</td>
<td>5.48 ± 1.32</td>
</tr>
</tbody>
</table>

Table 4.

Presence/Absence of Papilla Around Single-Tooth Implant in Relation to Distance (mm) From Contact Point to Bone Crest

<table>
<thead>
<tr>
<th></th>
<th>&lt;3</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<th>9</th>
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</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>(1)</td>
<td>(5)</td>
<td>(7)</td>
<td>(17)</td>
<td>(8)</td>
<td>(4)</td>
<td>(4)</td>
<td>(2)</td>
<td>(4)</td>
</tr>
<tr>
<td>% present</td>
<td>100</td>
<td>(1)*</td>
<td>100</td>
<td>(5)</td>
<td>100</td>
<td>(7)</td>
<td>88</td>
<td>(15)</td>
<td>50</td>
</tr>
<tr>
<td>% absent</td>
<td>0†</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
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</table>

Jemt Index Score

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>% present</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>% absent</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Percentage of papillae observed (N); Jemt Index 2 and 3 combined.
† Jemt Index 0 and 1 combined.
The present method of digitizing the intraoral radiographs increased the accuracy of the reading through a simple and inexpensive method.

The index described by Jemt has been utilized in the present study for a more descriptive and scientific evaluation of the presence or absence of papillae. When we carefully observe Table 4, a discrepancy between the simplified index with a presence or absence of papilla and the index score seems to appear. It should be recognized that an analysis of "present" or "not present" is subjective and that misinterpretation has been observed when related to score. Some papillae read as not present were, in fact, present at the half level and were a score 2—a much more positive and scientific evaluation.

The present data support the concept observed around teeth of the relationship between the papilla level and the distance from the contact point to the crest of the bone. Nearly the same values could be observed in this study adjacent to single-tooth implants. It seems reasonable to confirm the impact of the distance from the bone crest to the contact point to predictably determine the presence or absence of papillae. As observed by Tarnow et al. in a study on teeth, the present study demonstrates a shift in the presence or absence of papilla when the distance between the contact point to the interdental crest of bone is between 5 to 6 mm on a single-tooth implant. At 6 mm and above, some papilla is still observed (even at 9 mm or more) on teeth as well as single-tooth implants, but with no predictability. The regeneration of ginvial papillae after single-tooth implant treatment is successful with a distance of 5 mm between the contact point to the bony crest. Above 5 mm, the occurrence of papilla regeneration is at least 50% but with no predictability.

Because this study is cross-sectional and not prospective, it does not provide information about the possible creeping attachment that could occur within the 6 months between crown insertion and maturation of the adjacent gingiva. Moreover, since the contact point reference in this study is artificial, one could argue that some of the interpretations may be influenced by an artificially closed or open embrasure space. Nevertheless, the present study confirms a relationship between the marginal bone and soft tissue level. The soft tissue thickness, an average of 3.85 mm (SD = 1.04) as reported in Table 3, seems to be in accordance with the concept of biologic width around teeth and implants.

From the present investigation, we established that the papilla level around single-tooth implant restorations is mostly related to the bone level adjacent to the teeth and more specifically to the bone crest. The regeneration of papillae after single implant treatment is successful with a distance of 5 mm between the contact point to the bony crest. Above 5 mm, the occurrence of papilla regeneration is at least 50% but with no predictability.

A surgical technique at uncovering that aims to fill the embrasure space may considerably improve the result with an increased soft tissue thickness but may

<table>
<thead>
<tr>
<th>Jemt Index Score</th>
<th>N Papillae Observed</th>
<th>Overall Soft Tissue Height</th>
<th>Soft Tissue Height</th>
<th>N Conventional Tissue Height</th>
<th>N Modified Tissue Height</th>
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<tr>
<td>0</td>
<td>4</td>
<td>9.25 ± 1.15</td>
<td>3.60 ± 0.6</td>
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<td>9.25 ± 1.15</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>5.76 ± 0.56</td>
<td>3.76 ± 0.7</td>
<td>1</td>
<td>5.72</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>6.23 ± 1.89</td>
<td>3.70 ± 0.8</td>
<td>11</td>
<td>6.69 ± 1.91</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>5.95 ± 2.37</td>
<td>3.98 ± 1.2</td>
<td>17</td>
<td>6.26 ± 2.94</td>
</tr>
</tbody>
</table>
not always be mandatory if the final contact point related to bone crest is calibrated correctly.

REFERENCES


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