Two adjacent implant-supported restorations in the aesthetic region: A 10-year prospective case series

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Funding Information
Nobel Biocare AB. Grant/Award Number: 2004-288

Abstract
Introduction: The treatment outcome of two adjacent implant-supported restorations in the maxillary aesthetic region was assessed regarding peri-implant soft and hard tissues, and satisfaction during a 10-year follow-up period.

Methods: Twenty patients missing two adjacent teeth in the maxillary aesthetic region and treated with two implant-supported restorations were followed prospectively. The patients' clinical and radiographic parameters, as well as their satisfaction, were scored for a 10-year follow-up period.

Results: Seventeen patients' data were available for the 10-year follow-up. The survival rate of the implants and restorations was 100%. The 10-year mean peri-implant bone change at the side facing the adjacent tooth was $+0.11 \pm 0.57$ mm and at the side facing the adjacent implant was $-0.08 \pm 0.50$ mm. The peri-implant soft tissues were healthy and the patients' satisfaction was high, but the papilla-index showed compromised inter-implant papillae and low Pink Esthetic Scores. These figures were of the same magnitude at all time points.

Conclusion: While it is difficult to obtain sufficient inter-implant papillae and satisfactory Pink Esthetic Scores, the initial treatment results remained stable and the patients were satisfied with the final result throughout the 10-year follow-up period.

KEYWORDS
aesthetics, dental implants, papilla, peri-implant

Summary Box
What is known?
- Implant treatment of cases with two adjacent missing teeth can be rather unpredictable in terms of achieving a good aesthetic result.
- Only medium-term follow-up studies are known, reporting compromised inter-implant papillae.
What this study adds?
- Long-term evaluations showing that it is difficult to obtain satisfactory pink aesthetics with two adjacent implant restorations in the maxillary anterior region.
- Both the initial positive and negative treatment results remained stable over 10 years.
- Patients are satisfied with the treatment result after 10 years.

1 | INTRODUCTION

Long-term follow-up studies have published good results for single tooth dental implants and restorations in the aesthetic region.\(^1\)\(^-\)\(^5\) The establishment of harmonious soft tissues is of special interest in the aesthetic region.\(^6\)\(^-\)\(^8\) The presence of papillae is presumed to depend predominantly on the attachment level of the connective tissue fibers of the neighboring teeth and the mid-buccal mucosa level is dependent on the presence of a buccal bone layer at the implant.\(^9\)\(^,\)\(^10\)

Implant treatment of cases with two adjacent missing teeth in the maxillary aesthetic region is considered to be rather unpredictable in terms of achieving a good aesthetic result as there is no connective tissue attachment to support the papilla between the implants. Furthermore, the presence of interproximal papilla between two adjacent implant restorations depends on the distance between the contact point to the bone crest, as well as the mesio-distal distance between the implants.\(^11\)\(^,\)\(^12\) Souza and colleagues stated that, after a medium follow-up period, none of their cases had perfect anatomical papilla between the two implant-supported restorations.\(^13\) Furthermore, the preoperative bone conditions in the maxillary aesthetic region are often poor for the adjacent implants, which means that the bone and soft tissues often have to be restored in three dimensions with augmentation procedures that brings extra uncertainties for achieving good aesthetic results.\(^14\)\(^,\)\(^15\) Vigolo and colleagues reported a mean marginal bone loss of 0.8 ± 0.2 mm for unsplinted restorations in the maxilla after a 5-year follow-up period.\(^16\)

Several authors noted that, given the possible compromised aesthetic result with two adjacent implant-supported restorations compared with implant-supported restorations in a single tooth gap, it is remarkable that clinical studies on this subject are limited.\(^14\)\(^,\)\(^17\)\(^-\)\(^21\) Only three medium-term studies are known and no long-term studies.\(^22\)\(^-\)\(^24\)

Therefore, the purpose of this study was to assess the 10-year clinical, radiographic, aesthetic, and patient satisfaction parameters of two adjacent implant restorations in the maxillary aesthetic region.

2 | MATERIALS AND METHODS

The present prospective case series study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines. The patients had been referred to the University Medical Center Groningen (Groningen, the Netherlands) for implant treatment of two missing adjacent anterior maxillary teeth. Twenty consecutive patients treated between January 2005 and February 2008 who fulfilled the inclusion criteria were registered. The original protocol of the 1-year study was fully reviewed by the Committee and approved (UMCG IRB 20100072). This 10-year evaluation protocol underwent a short track review and was also approved (METc communication M22.293344) and registered in ClinicalTrials.gov (ID 202200150). Informed consent for the follow-up analysis was obtained from all the patients. The study’s design, group size, surgical and prosthetic procedures, patient characteristics, outcome measures, 1- and 5-year results have been described in detail before and therefore will only be described briefly here.\(^18\)\(^,\)\(^24\) The studied group was originally the control group of a randomized controlled trial.

2.1 | Inclusion and exclusion criteria

The original patients were selected on the basis of the following inclusion criteria: the missing or lost teeth were an incisor (central or lateral), a canine, or a first premolar in the maxilla; the missing teeth were adjacent to each other; the site had healed (at least 3 months after tooth removal); sufficient bone was available for the placement of two adjacent dental implants (if required, a bone augmentation procedure was performed at least 4 months before implant placement); sufficient space in the mesio-distal dimensions was available for the placement of two adjacent dental implants (the minimum dimensions were 10 × 3.5 mm) with an inter-implant distance of 3 mm and a tooth-implant distance of at least 1.5 mm; enough space was available in the mesio-distal, bucco-lingual, and interocclusal dimensions for the placement of two functional implant crowns with an anatomical design; the implant site was free from infection. The original study’s exclusion criteria were: presence of medical and general contraindications for the surgical procedures; presence of active and uncontrolled periodontal disease; bruxism; smoking; a history of local radiotherapy to the head and neck region.

2.2 | Surgical and prosthetic procedures

Under local anesthesia and the guidance of an analogical partially limiting surgical template, two implants (NobelReplace Groovy, Nobel Biocare AB, Gothenburg, Sweden) were placed with a maximum of 45 Ncm torque. If dehiscence had occurred, or the buccal bone thickness was less than 2 mm, a local bone augmentation procedure was performed. After a 3-month osseointegration period, the implants were uncovered and healing abutments were placed. An implant level impression was made within a week thereafter and single acrylic resin screw-retained provisional restorations were manufactured in a dental
laboratory and subsequently connected to the implants. Provisional restorations were manufactured following an anatomical design, ensuring enough space for the development of papillae. After a temporary phase of 3 months, a definitive crown was made. If after this maturation phase, the soft tissue papillae did not fill the entire approximal spaces, the design of the definitive restorations was adjusted to reduce black triangles. The definitive restoration consisted of an individually fabricated zirconia abutment (Procera, Nobel Biocare AB). Depending on the location of the screw access hole, the crowns were either screw-retained by fusing the porcelain directly to the abutment or cement-retained by means of a zirconia Procera coping (Nobel Biocare AB). Glass ionomer cement (Fuji Plus Cement, GC Europe, Leuven, Belgium) was used for the cement-retained crowns. Each patient was instructed in hygiene procedures and scheduled for routine maintenance recalls every 6 months.

2.3 | Clinical examinations

One month (T0), 5 years (T5), and 10 years (T10) after finishing the prosthodontic procedures, the soft tissues around the adjacent implant-supported restorations were clinically examined and scored with the following parameters: Papilla Index according to Jemt, Modified Bleeding Index according to Mombelli and colleagues and Gingiva Index according to Loe and Silness. Pocket probing depth was measured to the nearest millimeter using a manual periodontal probe (Williams Color-Coded Probe; Hu-Friedy, Chicago, IL) at three locations around the implants (at the side of the neighboring teeth, mid-buccally and at the side of the adjacent implants).

2.4 | Radiographic examinations

One month (T0), 5 years (T5), and 10 years (T10) after finishing the prosthodontic procedures, digital periapical radiographs were taken with the paralleling technique (Figures 1 and 2). The following linear measurements were made:

- the first bone to implant contact at the side facing the neighboring teeth;
- the first bone to implant contact at the side facing the neighboring implant;
- the inter-implant bone crest level.

2.5 | Photographic examinations

One month (T0), 5 years (T5), and 10 years (T10) after finishing the prosthodontic procedures, standardized photographs were made and analyzed. The level of the marginal gingiva was assessed by measuring mid-buccally the vertical distance of the incisal edge of the crown to the border of the gingiva (Figures 3 and 4).

2.6 | Professional’s aesthetic ratings

Aesthetic outcome (Pink Esthetic Score/White Esthetic Score [PES/WES]), as described by Belser and colleagues, was assessed from the digital photographs. The rating was applied to both implant restorations separately and scored at T0, T5, and T10.

2.7 | Patients’ satisfaction

The Meijndert and colleagues’ questionnaire was used to score the subjective appreciation of the results of the treatment at T5 and T10.

2.8 | Complications

Implant failure, restoration failure, and biological and technical complications were scored throughout the 10-year evaluation period. Peri-implant mucositis and peri-implantitis were calculated at implant level and patient level, according to the consensus reached at the 2017 World Workshop of the American Academy of Periodontology and European Federation of Periodontology, namely:
peri-implant mucositis is defined as a peri-implant mucosal inflammation in the absence of continuous marginal peri-implant bone loss, with the clinical signs: redness, swelling, bleeding on gentle probing, and suppuration;

peri-implantitis is defined as a pathological condition occurring in the tissues around dental implants, characterized by inflammation in the peri-implant connective tissue and progressive loss of supporting bone, with the clinical signs: inflammation and marginal peri-implant bone loss.

2.9 | Statistical analyses

All the analyses were performed at implant level, except for patient satisfaction and peri-implant mucositis/peri-implantitis. Data normality was tested with Q–Q plots and the Kolmogorov–Smirnov test. A paired t-test was used to analyze normally distributed data. If the data violated the assumptions of a normal distribution, differences between the groups were analyzed using the Mann–Whitney test. The Spearman’s rank correlation coefficient (Spearman’s ρ), with a 95% confidence interval, was calculated to assess the correlation between age at time of implant placement and papilla index, mean PES, mean WES, and mean mid-buccal mucosa level change at the 10-year follow-up. Furthermore, the correlation between applying bone augmentation and the papilla index, mean PES, and inter-implant crest level change at the 10-year follow-up was calculated with Spearman’s rank correlation coefficient (Spearman’s ρ). A significance level of 𝑝 = 0.05 was chosen for all the tests.

3 | RESULTS

The patients’ characteristics are presented in Table 1. All the patients attended the baseline evaluation (T₀). At the 5-year evaluation (T₅), one patient had moved whereupon the distance was too far to attend the follow-up visit. At the 10-year evaluation, another patient had moved without leaving a new address and one patient had changed their upper dentition into an implant-supported overdenture using the two implants for support. Among the remaining 17 participants, no implants or restorations were lost during the evaluation period, resulting in a 10-year implant survival rate of 100% and a 10-year restoration survival rate of 100%.

3.1 | Clinical, radiographic, and photographic assessments

The mean scores and standard deviations of the probing depth, Bleeding Index, and Gingiva Index at different time periods are given in Table 2. There were no significant differences in scores between the baseline (T₀) and T₅ and T₁₀, except for a significant but clinically irrelevant change in probing depth of the proximal side facing the adjacent tooth (significant difference between T₀ and T₁₀: 𝑝 = 0.029) and bleeding-index (significant difference between T₀ and T₁₀: 𝑝 < 0.001). Despite the group showing a compromised papilla presence, the scores were similar at all elevation periods (Table 3). Table 4 shows the peri-implant marginal bone changes, inter-implant crest level...
changes and the mid-facial marginal soft-tissue level changes. There were no significant differences in several factors between the T0-T5 and T0-T10 time periods, namely the marginal bone level facing the adjacent tooth (p = 0.932), the marginal bone level facing the adjacent implant (p = 0.970), the inter-implant crest level (p = 0.460), and the mid-facial marginal soft-tissue level (p = 0.889).

**TABLE 2** Means, standard deviations (SD), and significant differences in pocket probing depth (mm) (measured around the implants at the proximal sides facing the adjacent implant, mid-buccally and the proximal sides facing the adjacent tooth), mean bleeding index (SD) and gingival index (SD) of the peri-implant mucosa between the baseline (T0), and 5 (T5) and 10 years (T10) after definitive restoration placement.

<table>
<thead>
<tr>
<th></th>
<th>T0 (n = 40)</th>
<th>T5 (n = 38)</th>
<th>T10 (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probing depth proximal side facing adjacent tooth</td>
<td>3.4 (1.4)</td>
<td>3.2 (1.1)</td>
<td>2.7 (0.8)*</td>
</tr>
<tr>
<td>Probing depth mid-buccally</td>
<td>3.1 (0.9)</td>
<td>3.0 (1.8)</td>
<td>2.9 (0.7)</td>
</tr>
<tr>
<td>Probing depth proximal side facing implant</td>
<td>3.6 (1.3)</td>
<td>3.8 (1.2)</td>
<td>3.1 (0.8)</td>
</tr>
<tr>
<td>Bleeding-index (possible score 0–3)</td>
<td>0.9 (0.7)</td>
<td>0.6 (0.7)</td>
<td>0.4 (0.6)*</td>
</tr>
<tr>
<td>Gingival-index (possible score 0–3)</td>
<td>0.2 (0.4)</td>
<td>0.1 (0.2)</td>
<td>0.1 (0.3)</td>
</tr>
</tbody>
</table>

*Significant difference between the T0 and T10 probing depths of the proximal side facing the adjacent tooth (p = 0.029); the difference between the T0 and T10, bleeding index are significant (p < 0.001).

**TABLE 3** Frequency distribution of the papilla index scores up to 10 years after definitive restoration placement.

<table>
<thead>
<tr>
<th>Score</th>
<th>Tooth-implant</th>
<th>Implant-implant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T0 (n = 40)</td>
<td>T5 (n = 38)</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Score 0, no papilla formation; Score 1, less than half of the papilla is present; Score 2, at least half of the papilla is present; Score 3, the papilla approximately fills all the space; Score 4, papilla abundance; T0, evaluation directly after definitive restoration placement; T5, evaluation 5 years after definitive restoration placement; T10, evaluation 10 years after definitive restoration placement.

**TABLE 4** Means (SDs) of marginal bone level change (mm), inter-implant crest level change (mm), and mid-facial marginal soft-tissue level change in mm, 5 (T5) and 10 years (T10) after restoration placement and significant differences between the time periods.

<table>
<thead>
<tr>
<th>Bone level change</th>
<th>T5 (n = 38)</th>
<th>T10 (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal bone level facing the adjacent tooth</td>
<td>−0.65 (0.73)</td>
<td>−0.61 (0.57)</td>
</tr>
<tr>
<td>Marginal bone level facing the adjacent implant</td>
<td>−0.49 (0.64)</td>
<td>−0.48 (0.50)</td>
</tr>
<tr>
<td>Inter-implant crest level change</td>
<td>+0.03 (1.0)</td>
<td>−0.52 (0.46)</td>
</tr>
<tr>
<td>Soft tissue level change</td>
<td>T5</td>
<td>T10</td>
</tr>
<tr>
<td>Mid-facial marginal soft-tissue level change</td>
<td>−0.26 (0.50)</td>
<td>−0.28 (0.48)</td>
</tr>
</tbody>
</table>

### 3.2 Professional aesthetic ratings and patient satisfaction

The PES/WES rated the majority of patients as having moderate aesthetics, especially of the soft tissues. There were no significant differences between the time periods (Table 5). Overall patient satisfaction was 9.1 ± 0.8 and 9.3 ± 0.7 at the 5- and the 10-year evaluations, respectively; the difference is not significant (Table 6).

### 3.3 Complications

Peri-implant mucositis, calculated at implant level, was 50.0% and 41.2% at T5 and T10, respectively. Peri-implant mucositis, calculated at patient level, was 68.4% and 58.8% at T5 and T10, respectively. Peri-implantitis, calculated at both implant level and patient level, was 0.0% at all time periods.

Some technical complications occurred during the 10-year follow-up. A restoration screw became loose two times, which could be easily solved by fastening the screw again. Porcelain chipping also occurred two times. These chippings were minor and could be satisfactorily solved by some polishing without the need for a new restoration.

### 3.4 Influence of age on aesthetic outcome

Age at the time of implantation was not significantly correlated with the inter-implant papilla index (p = 0.053; 95% CI −0.451 to 0.531;
Inter-implant bone loss and it must be noted that Van Nimwegen studies did not report with a mean follow-up period of 4.3 years (10 patients with 20 adjacent implants in the upper jaw) and the Roccutto and colleagues retrospective study, with a mean follow-up of 4.0 years (7 patients with 14 implants in the upper or lower jaw) for comparison purposes.

The implant survival rate in the present prospective study (with 17 patients and 34 adjacent implants) was 100% and so comparable with both the Tymstra and colleagues study, which also reported 100%, and the Roccutto and colleagues study with a 93% survival rate (one implant was lost). The restoration survival rate was 100% in the present study, whereas the other two studies did not report this item.

The peri-implant soft tissues appeared healthy. The probing depths were small throughout the evaluation period, and the bleeding scores and gingival scores were low. Tymstra and colleagues and Roccutto and colleagues had comparable scores. It must be mentioned that all three studies were university-based meaning a strict inclusion protocol and strict follow-up protocol with respect to oral hygiene procedures and reinstruction.

At all time periods, the group showed a compromised papilla presence, especially between the two implants. This was also the case in the other two studies: in the majority of cases the papilla did not completely fill the approximal space between the tooth and implant and was even worse between the two implants. Roccutto and colleagues’ retrospective study showed that this was not only the case at the final follow-up evaluation, but also already at baseline. This finding is also in line with the Souza and colleagues study, which stated that none of the cases had perfect anatomical papilla between the two implant-supported restorations. The inter-implant bone crest and horizontal inter-implant distance is important for developing the inter-implant papilla. Moreover, the inter-implant bone loss should be kept to a minimum to maintain the inter-implant papilla.

3.5 Influence of bone augmentation procedures on aesthetic outcomes

A bone augmentation procedure in a separate session before implant placement was not significantly correlated with inter-implant papilla index \( p = 0.120; \ p = 0.647 \), inter-implant crest level change \( p = -0.265; \ p = 0.305 \) and mean PES \( p = -0.172; \ p = 0.509 \) at the 10-year follow-up.

4 DISCUSSION

Two adjacent implant-supported restorations in the maxillary aesthetic region showed a high implant survival rate, stable peri-implant bone and mid-facial mucosa levels, healthy peri-implant soft tissues, and high patient satisfaction during the 10-year follow-up period. The inter-implant papillae and pink aesthetics were scored as insufficient by the professionals, but they did not change over the 10-year evaluation period.

The results of the present 10-year follow-up study are comparable with other medium-term studies on the same topic, but long-term studies are missing. Three medium-term studies were found, being Tymstra and colleagues, Van Nimwegen and colleagues, and Roccutto and colleagues, but it must be noted that Van Nimwegen and colleagues’ results are included in the present study. Therefore, we could only use the Tymstra and colleagues retrospective study, with a mean follow-up period of 4.3 years (10 patients with 20 adjacent implants in the upper jaw) and the Roccutto and colleagues retrospective study, with a mean follow-up of 4.0 years (7 patients with 14 implants in the upper or lower jaw) for comparison purposes.

The mid-facial mucosa levels, healthy peri-implant soft tissues, and high patient satisfaction during the 10-year follow-up period. The Tymstra and colleagues study, stated that none of the cases had perfect anatomical papilla between the tooth and implant.

Note: The differences between the time periods are not significant. Abbreviations: PES, Pink Esthetic Score; WES, White Esthetic Score.

| TABLE 5 | Mean values (SD) of the aesthetic evaluation (PES/WES) at baseline, and the 5- and 10-year follow-ups. |
| --- | --- | --- | --- |
|  | \( T_0 \) (n = 40) | \( T_5 \) (n = 38) | \( T_{10} \) (n = 34) |
| PES | 5.2 (2.0) | 5.4 (1.4) | 5.2 (1.7) |
| WES | 8.2 (1.0) | 7.9 (1.2) | 7.7 (1.4) |
| PES/WES | 13.3 (2.6) | 13.3 (2.2) | 12.8 (2.5) |

Note: The differences between the time periods are not significant.

Overall score: Scale 0, completely dissatisfied to Score 10, completely satisfied. The mid-facial mucosa levels, healthy peri-implant soft tissues, and high patient satisfaction during the 10-year follow-up period. The Tymstra and colleagues study, stated that none of the cases had perfect anatomical papilla between the tooth and implant.

| TABLE 6 | Mean (SD) patient satisfaction questionnaire scores at the 5- and 10-year follow-ups. |
| --- | --- | --- |
|  | \( T_5 \) (n = 19) | \( T_{10} \) (n = 17) |
| Shape of the restoration | 3.7 (0.6) | 3.7 (0.8) |
| Color of the restoration | 3.7 (0.6) | 3.7 (0.8) |
| Shape of the mucosa | 3.4 (0.6) | 3.7 (0.5) |
| Color of the mucosa | 3.5 (0.6) | 4.0 (0.0) |
| Overall score (range 0–10) | 9.1 (0.8) | 9.3 (0.7) |

Note: Implant restoration and mucosa scores: Scale 0, completely dissatisfied; 1, dissatisfied; 2, neutral; 3, satisfied; 4, completely satisfied. Overall score: Scale 0, completely dissatisfied to Score 10, completely satisfied. There were no significant differences between the time periods.

\( p = 0.840 \), mean PES \( p = -0.109 \) 95% CI –0.571 to 0.405; \( p = 0.677 \), mean WES \( p = -0.066 \) –0.541 to 0.441; \( p = 0.802 \), or the mean mid-buccal mucosa level change at the 10 year follow-up \( p = 0.053 \) –0.451 to 0.531; \( p = 0.840 \).
with a provisional restoration and after placing the definitive restoration, remained rather stable. It must be noted that this limited bone loss does not mean that the peri-implant bone levels did not change after implant placement. The first radiographs used for the comparisons were taken after the definitive restoration placements. Some resorption could have happened during the healing and maturation phase. Peri-implant bone changes were not reported by Tymstra and colleagues but, in the Roccuzzo and colleagues’ study, the mean bone loss was very limited during the 4 years of functioning, not exceeding 0.2 mm at the sides facing the neighboring teeth and the sides facing the neighbouring implant. These results are comparable with the Vigolo and colleagues 5-year peri-implant bone loss study. Crest level change was not reported by either of the two studies. In our study, the mean horizontal distance was 3.8 mm between the two adjacent implants. Tarnow and colleagues noted that a horizontal inter-implant distance smaller than 3 mm will result in more bone crest loss. The greater distance in the present study could be the reason for the limited inter-implant crest level change.

Aesthetic outcome was rated by a professional with the PES/WES, as described by Belser and colleagues. The majority of the PES/WES scores rated the patients as having moderate aesthetics, especially of the soft tissues. There were no significant differences between time periods. In the other two studies, the professionals’ rating was done with different indices. Nevertheless, despite the three studies using different indices, one can conclude that the professionals rated the result as being far from excellent and more or less moderate, especially for the soft tissues. Apparently, a history of trauma with extended bone loss and difficulties to apply a successful vertical bone augmentation does have an impact on the final appearance.

Patient satisfaction was high after 10 years. Furthermore, the patients were satisfied with the shape and color of the mucosa and restoration. The patients in Tymstra and colleagues’ study also rated their overall satisfaction highly and were also satisfied with the mucosa and restoration. The provisional restorations were manufactured following an anatomical design, ensuring enough space for papillae development. However, if the papillae did not fill the entire approximal spaces after this maturation phase of the soft tissues, the design of the definitive restorations was adjusted to reduce black triangles. This procedure using provisional restorations to evaluate soft tissue forming gives the prosthodontist and dental laboratory the opportunity to design restorations, based on maximum information, for a harmonious final result which can have a positive effect on patient satisfaction. Roccuzzo and colleagues (2020) did not report on patient satisfaction. Meijndert and colleagues also noted that the patients were much more satisfied with the aesthetics than was expected, better than that rated by the professionals. Factors that are of importance to professionals may not have the same weight for patients.

The incidence of peri-implant mucositis at patient level was 68.4% and 58.8% at the 5- and 10-year evaluations, respectively. A paradox exists between the high peri-implant mucositis scores and the low bleeding-index scores and low gingival-index scores. In almost all the patients, the bleeding consisted of point-bleeding, which is scored as 1. If point-bleeding is noted at one of the implants, peri-implant mucositis will then also be assigned to the case. Moreover, difficulties with evaluating bleeding on probing properly around implants have been widely recorded. None of our patients showed signs of peri-implantitis during the evaluation period. In many of the patients, the bleeding-index did not exceed Score 1; if this correlates with limited infection, then this probably means the bone loss did not extend to ≥2 mm. Peri-implant infections were not calculated in other studies with two adjacent implants in the aesthetic region. Continuous eruption takes place in adults, especially in the upper incisors area. Implant placement in the anterior area of the maxilla may have an aesthetic impact, even in mature adults due to the continuous eruption of the adjacent teeth. However, we did not find a correlation between age at the time of implant placement and aesthetic outcomes. Furthermore, no new restorations or adjustments had to be made to restore the contact points and infra-occlusion, meaning that migration was not seen or minimal.

An extended bone augmentation procedure in an extra session prior to implant placement may be necessary because of excessive bone loss due to trauma. In this study, 9 of the 20 patients needed such an extended bone augmentation procedure. This could have had an impact on the aesthetic outcome. However, no correlation could be found between the bone augmentation procedure and inter-implant papilla presence, inter-implant crest level change, and soft tissue outcomes.

A strength of this study is the long evaluation period of 10 years. A limitation is the limited number of patients in the original study. Furthermore, a limitation is the lack of comparison with another treatment protocol, for example one implant with a crown and cantilever. Another limitation is that no data from the neighbouring natural teeth were collected, meaning that no additional analysis of the influence of them on peri-implant soft tissue outcomes is possible. A further limitation is that phenotype was not recorded in this study, leaving a possible influence on the aesthetic results unknown. Digital periapical radiographs were taken with the paralleling technique without a patient-specific stent for exact standardization, which is also a limitation of the study. Despite all these limitations, the treatment was tested in conventional clinical conditions which should help other experienced professionals obtain similar results.

5 | CONCLUSION

Within the limitations of this prospective 10-year case series study on two adjacent implant-supported restorations in the aesthetic maxillary region, it can be concluded that despite it being difficult to achieve a satisfactory PES result and sufficient inter-implant papilla, the initial treatment results remain stable over at least 10 years and patients appear to be satisfied with the final result during those 10 years.

AUTHOR CONTRIBUTIONS

Henny J. A. Meijer: concept/design, data collection, data analysis/interpretation, drafting article and approval of article. Kees Stellingisma: data collection, critical revision of article and approval of article. Arjan Vissink: data analysis/interpretation, critical revision of article, and
acknowledgments

The authors express their gratitude to Dr N. Tymstra and Dr W. G. van Nimwegen for the initial work. The 1-year study was funded by means of materials from Nobel Biocare AB (Göteborg, Sweden), Grant #2004-288. No funding was obtained for the 5- and 10-year analyses.

conflict of interest statement

The authors declare no conflicts of interest.

data availability statement

Upon reasonable request.

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REFERENCES


