Esthetic Evaluation of Maxillary Single-Tooth Zirconia Implants in the Esthetic Zone

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The purpose of this study was to evaluate ceramic dental implants using different esthetic scores. A total of 53 ceramic dental implants were evaluated using the Pink Esthetic Score (PES), White Esthetic Score (WES), and Peri-Implant and Crown Index (PICI). Prosthodontists, orthodontists, oral surgeons, and dentistry students independently performed assessments. The mean value of combined PES + WES was 17.4 points, and the PICI was 523.2 points. Orthodontists assessed a significantly lower result in both indices compared to all other assessor groups (P ≤ .05). Patient satisfaction was very high. The esthetic scores around ceramic implants were considerably higher than the suggested threshold of clinical acceptability. Int J Periodontics Restorative Dent 2019;39:e195–e201. doi: 10.11607/prd.3282

The development of high-strength oxide ceramics, such as alumina and zirconia, for use in dental implantology provided new metal-free treatment options for patients and clinicians. Currently, zirconia is the material of choice for the fabrication of ceramic dental implants.¹

Most zirconia implants are manufactured as one-piece implant systems because of the limitations of the material. Technical failure such as implant fracture, especially in two-piece systems, is a major problem.² In a review, Pieralli et al³ stated that additional studies are needed to confirm the long-term predictability of zirconia implants. Due to this lack of long-term data, zirconia implants cannot yet be recommend for routine clinical use.¹ Clinical data on relevant technical and biologic factors affecting implant success and patient satisfaction are required in particular.² Laboratory investigations have shown that zirconia implants might have the ability to withstand oral forces.¹,⁵ Furthermore, it has been demonstrated that zirconia might be favorable for the formation of epithelial attachments and for mucosal conditions,⁶ which could be seen as important prerequisites for preventing peri-implant infections. Several investigations have shown significantly reduced bacterial adhesion on zirconia surfaces in comparison to titanium surfaces⁷,⁸
and fewer inflammatory cells in the peri-implant soft tissue of zirconia in comparison to titanium and other metals.\textsuperscript{6,9}

With regard to the clinical application of zirconia dental implants, little evidence-based scientific data is available. A prospective clinical study reported success and survival rates for zirconia implants of 95.6\% after 1 year.\textsuperscript{10} Peri-implant soft and hard tissue behavior was reported to be favorable.\textsuperscript{11,12} As modern zirconia implants with a microrough surface topography may have the potential to become an alternative to titanium for the fabrication of dental implants, and because limited published data from clinical investigations are available, further science-based clinical results of commercially available zirconia dental implants are of great significance. The purpose of this study is to evaluate the soft tissue appearance of single-tooth zirconia-dioxide implants in the maxillary esthetic zone using the Pink Esthetic Score (PES), White Esthetic Score (WES), and Peri-Implant and Crown Index (PICI).\textsuperscript{13,14}

**Materials and Methods**

**Patients**

A total of 52 patients with 53 ceramic dental implants were included in this methodologic assessment. Patient 14 received 2 implants. At the time of this retrospective study, the crowns had been in place for at least 12 months after implantation (range 12 to 15 months). The study was approved by the local ethical commission. Patients were inspected clinically, and standardized 90-degree clinical photographs were taken with a commercially available digital camera (Nikon D3S, Micro-Nikkor 105 mm). The final reconstructions consisted of zirconia-dioxide monotype implants (Straumann PURE Ceramic Implants with ZLA surface, Straumann) with cemented crowns (Ketac Cem, 3M ESPE). In cases of alveolar atrophy, autologous bone augmentations were performed if necessary, strictly avoiding bone substitutes. In three cases, soft tissue conditions were surgically corrected using frenulotomy.

Photographs of the 52 patients were rendered anonymous and randomized in order. This resulted in 53 photographs of implants and crowns for evaluation by the participants. A total of 12 examiners (3 oral surgeons, 3 orthodontists, 3 prosthodontists, and 3 dentistry students) received the 53 cases, an information sheet with instructions regarding each index, and data sheets for each index.

The PES, WES, and PICI were evaluated and used in this study based on Fürhauser et al\textsuperscript{15} and Belser et al.\textsuperscript{14} The combined PES + WES was used to evaluate the pink and white of single ceramic implant reconstructions by comparison with the contralateral tooth considering five pink and five white criteria. The PICI was evaluated analyzing pink and white esthetic characteristics.

**Pink Esthetic Score/White Esthetic Score**

The PES, previously described by Fürhauser et al,\textsuperscript{15} comprises the following five variables: mesial papilla, distal papilla, curvature of the facial mucosa, level of the facial mucosa, and root convex/soft tissue color and texture at the facial aspect of the implant site. A score of 2, 1, or 0 was assigned to each of the five PES parameters. The two papillary scores (mesial and distal) were assessed for complete presence (2), incomplete presence, (1), or absence (0) of papillary tissue. All other soft tissue parameters were evaluated as identical (2), slightly different (1), or markedly different (0) compared to the natural control tooth. The five described parameters add up, under optimum conditions, to a maximum score of 10 (Table 1).

The WES, previously described by Belser et al,\textsuperscript{14} specifically focuses on the crown restoration itself and is based on five parameters: general tooth form; outline and volume of the clinical crown; color, which includes assessment of the dimension's hue and value; surface texture; and translucency and characterization. All five parameters are analyzed by direct comparison with the natural, contralateral reference tooth, estimating the degree of match or mismatch. A score of 2 (identical), 1 (slightly different), or 0 (markedly different) was assigned to all five parameters. In the case of a perfect esthetic result compared to the control tooth, a maximum WES of 10 is possible (Table 1).
The highest possible combined PES + WES score was 20, which represents a close match of the peri-implant soft tissue conditions and the clinical implant crown compared to the contralateral natural tooth site.

**Peri-implant and Crown Index**

The PICI, previously described by Tettamanti et al., includes three pink, three white, and three subjective overall criteria, each ranging from 0 to 100 points on a visual analog scale. For the pink and white esthetics, a score of 0 indicates that the implant reconstruction is completely different from the contralateral tooth, whereas a score of 100 indicates that the implant crown restoration is identical to the contralateral tooth. For the three subjective overall categories, the same scale was used, ranging from 0 points (not esthetic at all) to a maximum of 100 points (very esthetic) (Table 1).

Patient satisfaction was evaluated with a standardized questionnaire for every single implant. Patients were asked to grade the complete implant crown restoration from 1 (perfect result, no complaints at all) to 6 (very poor result). Pink and white esthetics were assessed at the same time.

**Statistical Analyses**

All analyses were performed with the software SPSS 22 (IBM) using Wilcoxon test. The level of statistical significance was set at $P \leq .05$.

**Results**

Photographs were obtained from patients who had a single maxillary gap in the esthetic zone from second premolar to second premolar replaced by a single ceramic implant and crown. The combined PES + WES value ranged from 12.9 to 19.3 points with a mean value of 17.4

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**Table 1 Criteria and Calculation of the Esthetic Indices**

<table>
<thead>
<tr>
<th>Variable</th>
<th>0</th>
<th>1</th>
<th>2</th>
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</thead>
<tbody>
<tr>
<td><strong>Pink Esthetic Score</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mesial papilla</td>
<td>Missing</td>
<td>Incomplete</td>
<td>Present</td>
</tr>
<tr>
<td>Distal papilla</td>
<td>Missing</td>
<td>Incomplete</td>
<td>Present</td>
</tr>
<tr>
<td>Curvature of the facial mucosa</td>
<td>Large deviation</td>
<td>Small deviation</td>
<td>No deviation</td>
</tr>
<tr>
<td>Level of the facial mucosa</td>
<td>Large deviation</td>
<td>Small deviation</td>
<td>No deviation</td>
</tr>
<tr>
<td>Root convexity / soft tissue color and texture at the facial aspect of the implant site</td>
<td>Large deviation</td>
<td>Small deviation</td>
<td>No deviation</td>
</tr>
<tr>
<td><strong>Maximum:</strong> 10 points</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>White Esthetic Score</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tooth form</td>
<td>Large deviation</td>
<td>Small deviation</td>
<td>No deviation</td>
</tr>
<tr>
<td>Outline/volume</td>
<td>Large deviation</td>
<td>Small deviation</td>
<td>No deviation</td>
</tr>
<tr>
<td>Color (hue/value)</td>
<td>Large deviation</td>
<td>Small deviation</td>
<td>No deviation</td>
</tr>
<tr>
<td>Surface texture</td>
<td>Large deviation</td>
<td>Small deviation</td>
<td>No deviation</td>
</tr>
<tr>
<td>Translucency</td>
<td>Large deviation</td>
<td>Small deviation</td>
<td>No deviation</td>
</tr>
<tr>
<td><strong>Maximum:</strong> 10 points</td>
<td></td>
<td></td>
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<tr>
<td><strong>Peri-implant and Crown Index</strong></td>
<td>Visual scale 0–100 points for each parameter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Papillae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zenith</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Root convexity</td>
<td></td>
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<td></td>
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<tr>
<td>Shape</td>
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<td></td>
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<tr>
<td>Color</td>
<td></td>
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<tr>
<td>Characterization</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Maximum:</strong> 600 points</td>
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</table>
The mean total PES was 8.8 (range: 5.5 to 10.0), and the mean total WES was 8.6 (range: 5.5 to 9.8). The lowest PICI result was 432.8 points and the highest was 567.9 points, with a mean value of 523.2 points. Figs 1 and 2 show patients with high (Fig 1) and low (Fig 2) PES + WES and PICIs.

The comparison between the four different groups regarding PES + WES and PICI revealed the highest values in the student group for both indices (PES + WES, 18.1 points; PICI, 541.4 points) (Figs 3 and 4). There was a significant difference between students and all other groups for both indices, except for PES + WES between students and oral surgeons (P = .215). Orthodontists showed significantly lower values for PES + WES (16.1 points) and PICI (502.6 points) than the other three groups (Figs 3 and 4). No significant difference was found between prosthodontists and oral surgeons (P = .057).

Comparing PICI with the PES + WES index, a significant difference was measured between prosthodontists and oral surgeons. However, as shown in Fig 4, the PICI showed no significant difference between oral surgeons and students (P = .008).

Patient satisfaction was assessed with a standardized questionnaire for every single implant (n = 53). Patients graded the complete implant crown restoration from 1 (perfect result, no complaints at all) to 6 (very poor result). Results revealed a mean value of 1.2. Patients did not grade any implant restoration higher than 3.

**Discussion**

Several studies have attempted to assess the esthetic result of dental implant rehabilitations. The PES, focusing on the peri-implant soft tissue, was initially presented by Fürhauser et al.\(^\text{15}\) Subsequently, the modified PES + WES index was described by Belser et al.\(^\text{14}\) The PES + WES has recently become a distinguished index for the objective evaluation of the esthetic soft tissue outcome of anterior single-tooth implants.\(^\text{16}\)
In the literature, clinical acceptability was defined as modified PES > 6 and WES > 6 by Cosyn et al\textsuperscript{17} and Belser et al.\textsuperscript{14} Furthermore, unfavorable mucosal esthetics was defined as < 6 for both scores. Threshold of clinical acceptability was set at PES + WES ≥ 12 points and PICI ≥ 360 points after Tettamanti et al\textsuperscript{13} and Jones and Martin.\textsuperscript{18} Tettamanti et al\textsuperscript{13} concluded that PES + WES and PICI seem to be suitable as esthetic indices for single implant crowns. Esthetic indices are an ideal tool to evaluate and compare data from clinical investigations and different implant designs. In the present study, the total PES + WES result was 17.4 points (maximum 20). The mean total PES was 8.8 points (maximum 10), and the mean total WES was 8.6 points (maximum 10). The PICI mean value was 523.2 points (maximum 600). All mean values ranged considerably over the threshold of clinical acceptability mentioned above. Even the minimum PES + WES value of 12.9 points passed the threshold of ≥ 12. Only publications assessing modified PES + WES were compared to the current study, and only titanium implants were compared as zirconia implants have not yet been investigated in terms of PES + WES.

Belser et al\textsuperscript{14} showed data for 45 titanium implants with a mean total PES of 7.8 points. The mean total WES was 6.9 points, resulting in a total PES + WES of 14.7.\textsuperscript{14} Likewise, in 31 patients with 48 titanium implants mean PES was 7.2 points after an average time of 5 months from implantation.\textsuperscript{19}

In another study investigating 20 patients with single titanium implants, the mean PES value was 8.25 points after 6 years.\textsuperscript{20} In an assessment of 27 cases, the mean PES was 5.7 points, the mean WES was 6.2 points, and the mean total PES + WES was 11.9 points (range: 6 to 20 points).\textsuperscript{18} Similarly, the mean PES + WES after a mean follow-up time of 31 months by Mangano et al\textsuperscript{21} was 14.50 points for immediately placed and 15.61 points for conventionally placed implants.
In a long-term study up to 22 years by Dierens et al., postoperative esthetics was judged poor (mean PES 7.42; mean WES 5.43) and a significant time improvement could not be demonstrated.

Titanium results seemed to be less favorable compared to those of zirconia implants, as 12% of 26 restorations scored < 12, which was considered as the threshold of clinical acceptability. In this evaluation, 26 anterior maxillary single-tooth implants were examined after 2 years with a mean total PES + WES of 14.30 points, a mean PES of 7.30 points, and a mean WES of 7.00 points. Timing of implant placement did not influence papillary dimensions; however, esthetic failures seemed to be rather common (24%), with only a strict minority of cases (8%) showing perfection. Most cases (68%) demonstrated acceptable esthetics. Only one publication found similar values compared to the present study, with a mean PES of 8.3 points and a mean WES of 9.5 points for a total PES + WES of 17.8 points after 1.5 to 5.5 years of observation. Although studies have shown that different dental disciplines differ in their critical view, the assessment of Paul et al. was evaluated from one group. In a study by Cho et al., the PES + WES evaluation was performed by two periodontists, two prosthodontists, two orthodontists, and two senior dental students. PES + WES was 11.19 points, mean PES was 5.17 points, and mean WES was 6.02 points. Orthodontists were clearly more critical than the other groups. This is in agreement with the present study, where orthodontists showed the lowest values by a significant amount. Dentistry students assessed the highest PES + WES and PICI values.

Conclusions

Mean esthetic index values around ceramic implants scored considerably higher than the threshold of clinical acceptability. Orthodontists were the most critical examiners compared to all other groups. Dentistry students presented the highest ratings. Patient satisfaction regarding the implant crown reconstruction was very high.

Acknowledgments

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References


