

RESEARCH AND EDUCATION

Validity and reliability of a proposed anterior implant esthetic index (AIEI)



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Advances in dental implant research, their design, and their clinical application have transformed oral health care. Improved protocols in dental implant therapy have made implant-supported restorations biologically and mechanically predictable.^{1–7} The use of dental implants to support restorations in the esthetic zone has also increased.^{8–14} At the same time, patients have become more esthetically demanding and have sought optimal outcomes.^{8–15}

Patient satisfaction and esthetic acceptance have become important factors in predicting the success of implant therapy in the anterior maxilla.^{16–21} Recognizing patient expectations assists with improved treatment outcomes and patient satisfaction.^{10,21,22} The different perspectives of

ABSTRACT

Statement of problem. Patient satisfaction and esthetic acceptance are important factors in predicting the success of implant therapy in the anterior maxilla. A standardized esthetic index to evaluate implant esthetic outcomes is still lacking.

Purpose. The purposes of this study were to describe the newly developed images that correlate to the pink esthetic score and white esthetic score (PES/WES) for improved standardized documentation and to evaluate the validity and reliability of the proposed anterior implant esthetic index (AIEI) with patient satisfaction scores.

Material and methods. A photograph deemed ideal (perfect score of 2) using the PES/WES criteria was acquired and digitally altered to represent scores of 1 (minor discrepancy) and 0 (major discrepancy) according to the PES/WES guidelines. A pilot study enrolled prosthodontists and periodontists to review and verify the representations. A 29-question survey was developed and distributed to 33 participants on a tablet computer to evaluate the photographs. The participants were asked about their satisfaction level with the photographs on a visual analog scale from 0 to 100. Data were extracted, and ANOVA was used to compare mean satisfaction scores. Post hoc Tukey tests were used to analyze the differences within each variable ($\alpha=.05$).

Results. Standardized sets of 14 altered PES and 14 altered WES photographs were generated. The interrater reliability ($n=5$) of the pilot study showed moderate agreement with $\kappa=0.453$ (95% CI: 0.431–0.476) for all and individual scores. Based on the patient survey, 5 of the 14 factors of the PES/WES showed no significant difference and were eliminated when constructing the index. Using scores and percentages, the anterior implant esthetic index was developed for scores of 0, 1, and 2 for each of the remaining 9 criteria. The maximum score for the index was 20 points.

Conclusions. Photographic representation of each criterion within the PES/WES standardized the patient's ability to evaluate anterior implant esthetics. An anterior implant esthetic index was developed, and a moderate interrater reliability agreement and good validation with patient satisfaction scores were obtained. (J Prosthet Dent 2025;133:1294-1303)

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Clinical Implications

Tooth color, mesial papilla, distal papilla, and soft tissue color were the principal factors in determining patient satisfaction in anterior implant esthetics. The alveolar process, soft tissue contour, soft tissue texture, tooth form wide, and tooth surface texture had minimal influence on patient satisfaction.

patients and clinicians on implant-supported restorations esthetic outcomes have been reported.^{9–12,14,23–25} In general, clinicians tend to be more critical of the esthetic outcomes than patients.¹⁰ However, literature on patient-centered outcomes with dental implants is lacking.^{26,27} This finding highlights the importance of the need to review patient-centered esthetics as part of the overall process.¹⁹

In addition, an objective and reproducible esthetic score system for the dental implant restoration and the peri-implant soft tissues is needed to focus dental implant research on esthetics.²⁸ Parameters and indices have been introduced to assess the success of the natural lifelike implant-supported restoration and surrounding peri-implant soft tissues. Furhauser et al²⁸ developed the 7 criteria pink esthetic score (PES) to objectively evaluate the peri-implant soft tissue, which was found to have good intra-examiner agreement.²⁹ Belser et al²³ developed the white esthetic score (WES) to objectively evaluate implant-supported restorations based on 5 criteria. They also simplified the PES into 5 criteria and combined it with the WES to evaluate anterior implant-supported restorations and their surrounding soft tissue.²³ Other systems have also been developed, including the papilla index,³⁰ the implant crown esthetic index,³¹ the subjective esthetic score,³² the complex esthetic index,³³ the Copenhagen index score,³⁴ and the implant restorative esthetic index,³⁵ but these have not been as widely used as the PES/WES. Correlations between the PES/WES and patient satisfaction determined on a visual analog scale with poor to moderate correlation have been reported.^{8,9,11,15,19,21,35–39} Therefore, comparisons between studies using various esthetic indices should be evaluated and interpreted with caution.^{10,21,40–42}

A comprehensive and practical index should be developed to evaluate the esthetic outcomes of the implant-supported restoration in the esthetic zone before definitive insertion or as a research documentation step.^{10,38} Although the current PES/WES is an excellent tool in evaluating implant esthetic outcomes,²⁹ the level of subjectivity is fairly high. This subjectivity can be minimized if users of the PES/WES can refer to and

follow a set of standardized photographs for each of the factors in the PES/WES.³⁷ To compare the esthetic results of different treatment modalities using the PES/WES for future research, these indices should also correlate with patient satisfaction. Improving the correlation between clinician-determined PES/WES scores and subjective patient satisfaction scores is needed.

The purposes of this study were to describe and validate newly developed images to correlate with PES/WES for anterior dental implant restorations, to validate the newly proposed Anterior Implant Esthetic Index (AIEI) with patient satisfaction scores, and to assess its reliability. The null hypothesis was that all criteria of the PES/WES would be equal in significance in patient satisfaction with anterior implant esthetics.

MATERIAL AND METHODS

The workflow of the study is depicted in [Figure 1](#). The first objective was to produce a set of photographs that described and validated the scores of the PES and WES, allowing clinicians and researchers to have a definitive guide for each score. The clinical photographs served as a guide for ideal, minor, and major discrepancies. The development of the AIEI was as follows: a photograph deemed ideal (perfect score of 2) using PES/WES criteria^{23,28} of the 6 maxillary anterior teeth ([Fig. 2](#)) was obtained by a dentist (G.S.) using a digital single-lens reflex camera (Canon 60D, Canon U.S.A., Inc) with a focal length of 100 mm, aperture f 29, and exposure time of 1/200 seconds. The 7 esthetic factors in the original PES (mesial papilla, distal papilla, level of soft tissue margin, soft tissue contour, alveolar process, soft tissue color, and soft tissue texture) were used as components of the new AIEI. Changes were made to the original 5 esthetic factors in the WES. Tooth form was expanded to 2 criteria: when the tooth appears too wide or too narrow. The original tooth color factor involved hue and value. In the AIEI, tooth color involved hue and chroma. The original translucency factor of the WES was expanded into 2 parts: “Does the restoration appear too translucent or low in value” or “Does the restoration appear too opaque or high in value.” The subsequent 28 photographs were digitally altered versions of the initial ideal scoring photograph by following guidance from previous studies ([Table 1](#)).^{23,43,44} A score of 1 was designated as a minor discrepancy, and a score of 0 was designated as a major discrepancy for each of the 14 criteria. An independent biomedical illustrator performed the alterations under the guidance of the authors. All photographs were altered by using a software program (Adobe Photoshop 5.0.2; Adobe Systems Inc).

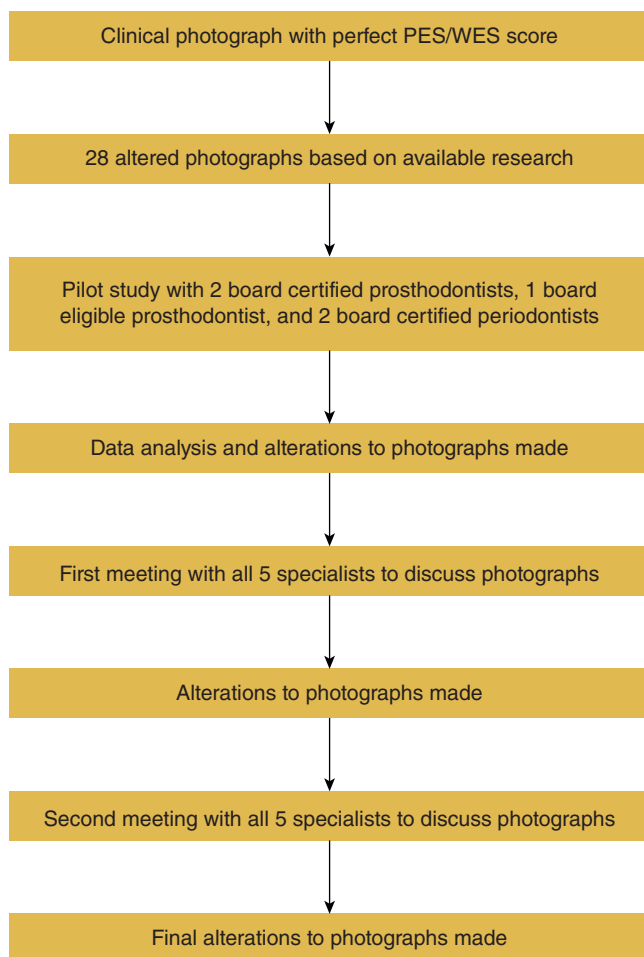


Figure 1. Research design flow chart.

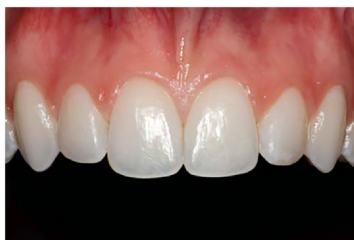


Figure 2. Ideal photograph shows dental implant restoration of right maxillary central incisor that would score 2 (highest) in every factor in PES and WES. PES, pink esthetic score; WES, white esthetic score.

The photographs were in a 1:1 size ratio to simulate how patients would view an anterior dental implant-supported restoration in real life.

For each of the 28 altered photographs, 1 PES/WES criterion was altered to represent scores 1 and 0 for that particular criterion by following the initial criteria from the previous study (Figs. 3, 4).²⁸ The degree of alteration for some criteria was based upon previously established thresholds.^{43,44} Criteria that did not have previous research on noticeable thresholds were altered to be

clinically relevant as determined by a group of 2 prosthodontists and 1 periodontist from the University of Illinois Chicago, College of Dentistry. If 2 of the 3 agreed the photograph accurately represented the score, then no further alterations were made. If fewer than 2 agreed on the scoring, a meeting was held to discuss the additional changes required to reflect the required score. The evaluating specialists then reviewed and rescored all photographs until a consensus was reached that the representations accurately captured the alterations.

The intended scores for each photograph were verified in a pilot study. The Delphi-like method was applied to gain consensus through controlled feedback from a different panel of clinicians.⁴⁵ Altered photographs, with scores of 1 or 0 for each of the criteria, were presented to each of the 5 evaluating specialists, 2 board certified prosthodontists, 1 educationally qualified prosthodontist, and 2 board certified periodontists.⁴⁶ Statistical analyses were performed for interrater and intrarater reliability by evaluating the scores for several time points during the pilot study period. Assessment of interrater reliability was performed using the Fleiss kappa (κ) for 5 raters, and assessment of interrater reliability was performed using the intraclass coefficient (ICC). A κ coefficient of <0.2 indicated slight agreement, 0.2 to 0.40 as fair agreement, 0.41 to 0.60 as moderate agreement, 0.61 to 0.80 as substantial agreement, and >0.80 as almost perfect agreement.^{46,47}

Validation of the AIEI was performed using the patient satisfaction questionnaire with recruited patients. A photographic questionnaire containing 1 ideal and 28 digitally altered (nonideal) photographs of anterior dental implant-supported restorations was developed. The experimental protocol was approved by the University of Illinois Chicago Institutional Review Board (IRB #2012-0396).

A patient satisfaction survey with 29 images was developed based on ideal and altered photographs. For each of the 29 images, participants were asked "How satisfied are you with the esthetic outcome of the front teeth and gums if this were your mouth." Participants indicated their satisfaction level by moving the indicator along the visual analog scale from 0 (very unsatisfied) to 100 (very satisfied).^{8,15,23}

The initial page of the survey offered a description of the study, followed by a consent form. Once consent had been provided, participants were evaluated for colorblindness, and instructions for completion of the survey were provided (Fig. 5). The participants were alerted that the maxillary right central incisor was an implant-supported restoration in the photograph. The participant could view each photograph for a maximum of 30 seconds, after which the image would disappear. A pause button was available for the participants, and the screen would turn a solid 18% gray when paused.

Table 1. Summary of PES and WES criteria condensed from Belser et al²³

PES			
Parameter	Absent	Incomplete	Complete
Mesial papilla	0	1	2
Distal papilla	0	1	2
	Major Discrepancy	Minor Discrepancy	No Discrepancy
Curvature of facial mucosa	0	1	2
Level of facial mucosa	0	1	2
Root convexity/soft tissue color and texture	0	1	2
Maximum total PES score			10
WES			
Parameter	Major Discrepancy	Minor Discrepancy	No Discrepancy
Tooth form	0	1	2
Tooth volume/outline	0	1	2
Color (hue/value)	0	1	2
Surface texture	0	1	2
Translucency	0	1	2
Maximum total WES score			14

PES, pink esthetic score; WES, white esthetic score.

Participants were also instructed not to focus in on any photographs but to keep all photographs life-sized, with the height of the central incisor being 10.5 mm.

For the patient satisfaction survey, all 29 photographs were presented to the participants in a randomized order, not grouped by criteria. For this study, the lips and face were not included in the photographs. Criteria for inclusion in the study population stated that each participant had to be 18 years of age or older, provide informed consent, and understand English. Exclusion criteria included those individuals with known colorblindness. Colorblind individuals were identified by a simple Ishihara test (<https://colormax.org/color-blind-test/>) at the beginning of the survey. A total of 4 Ishihara plates were used, and participants were deemed not colorblind if they were able to see all 4 numbers on the plates.

Participants completed the survey on a tablet computer (Apple iPad; Apple Inc) available to dentists and patients receiving dental care at the University of Illinois Chicago, College of Dentistry in the Advanced Prosthodontics Clinic and the Implant and Innovations Center. The participants completed the survey while sitting in the dental chair. The website was hosted by an independent company (Netfirms Inc), and the data were automatically stored online where they could be easily retrieved for analysis. Data were stored only when the participants had completed the entire survey.

Data were extracted and exported to a spreadsheet (Excel; Microsoft Corp) for data cleaning. ANOVA was used to compare the mean satisfaction scores for each of the 3 photographs with a score of 0, 1, or 2 (ideal photograph) for each variable. Post hoc Tukey tests were used to analyze the differences within each variable ($\alpha=.05$).

RESULTS

The interrater reliability ($n=5$ raters) of 3 prosthodontists and 2 periodontists of complete data (pilot study) showed moderate agreement with $\kappa=0.453$ (95% CI: 0.431–0.476)

for all scores, $\kappa=0.427$ (0.397–0.456) for the rating of scores 0, $\kappa=0.279$ (0.249–0.309) for the rating of scores 1, and $\kappa=0.589$ (0.560–0.619) for the rating of scores 2. The ideal esthetic score would be a 2 based on the scale developed by Furhauser et al²⁸ (Fig. 2). The standardized set of 14 altered (nonideal) PES photographs are presented in Figure 3 and altered (nonideal) WES photographs in Figure 4. Modifications for each of the 14 criteria are shown with values generated for 1 and 0 on the Furhauser scale (Table 1).²⁸ Detailed explanations for each scoring value accompany the photographs.

Thirty-three participants completed the survey in a controlled environment. Within the patient group, 9 of the 14 esthetic factors had a statistically significant difference ($P<.05$) in satisfaction scores between score 0, 1, and ideal (2) photographs, showing good validity of the 9 esthetic factors. The 5 esthetic factors that did not show a statistically significant difference in satisfaction scores between the scores 0, 1, and ideal (2) photographs were alveolar process, tooth surface texture, tooth form wide, soft tissue contour, and soft tissue texture. Tooth color was the only factor where satisfaction scores for 0, 1, or 2 (ideal) were all significantly different from each other ($P<.05$). The other 8 factors showed a difference between the ideal image and the other 2 scoring images. For all 9 factors that showed statistical differences, patient satisfaction decreased as the esthetic factors varied from ideal (2) on the images. After eliminating the 5 factors that were not significant, a table was generated showing satisfaction scores among patients for the remaining 9 factors and percentages based on 77 as 100% (Table 2). The numeric AIEI was calibrated by using percentages and satisfaction scores and is presented in Table 3.

DISCUSSION

The null hypothesis that all criteria of the PES/WES would be equal in significance in patient satisfaction

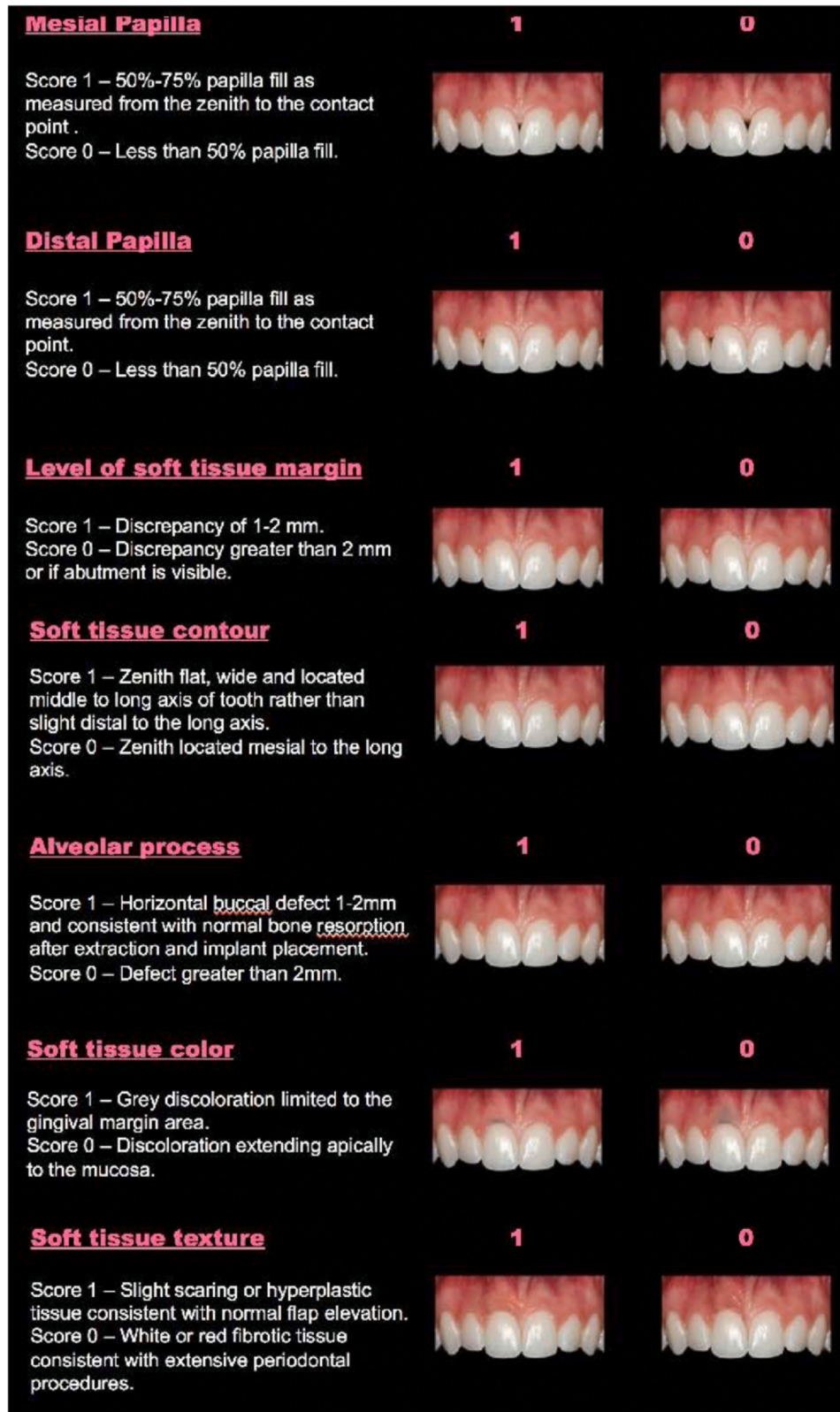


Figure 3. Standardized set of 14 altered PES photographs. PES, pink esthetic score.

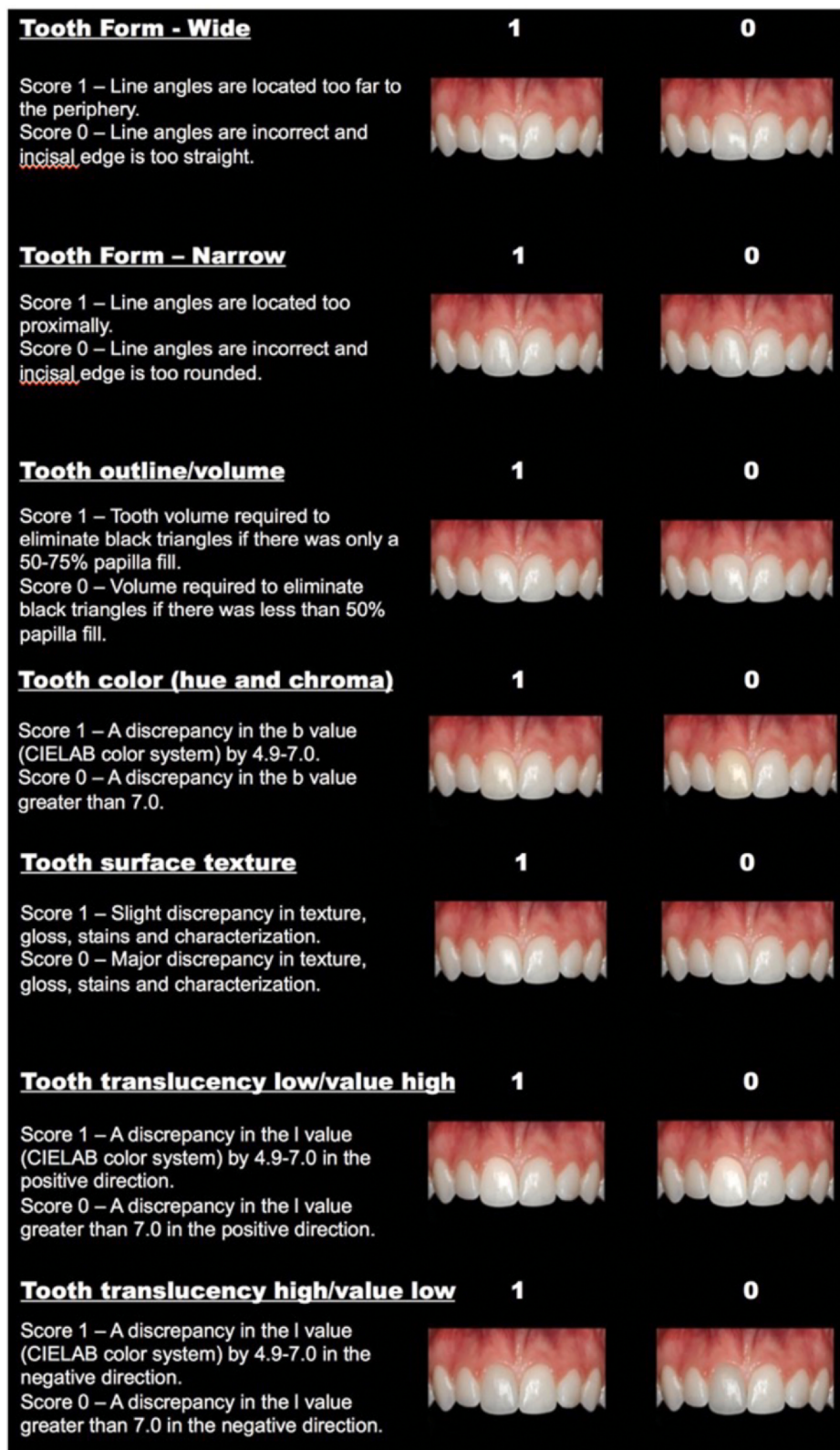


Figure 4. Standardized set of 14 altered WES photographs. WES, white esthetic score.

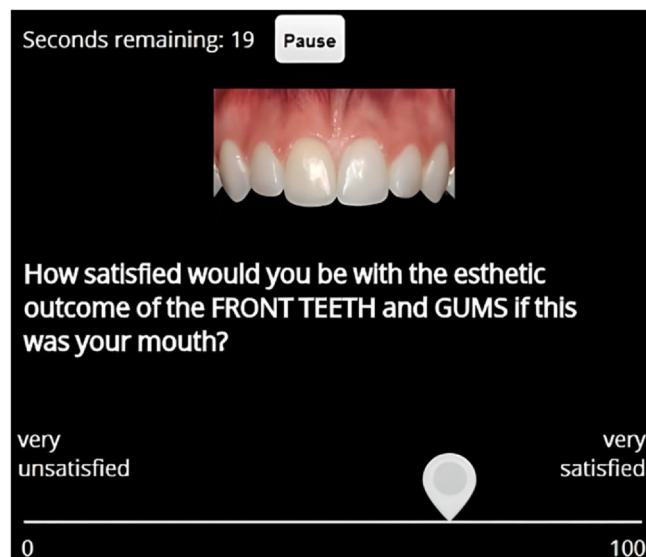


Figure 5. Sample image from patient satisfaction survey.

with anterior implant esthetics was rejected because some PES/WES criteria were significantly more important to patient satisfaction and others were not critical and could be eliminated when evaluating patient satisfaction. The first aim of this study was to modify the existing PES/WES to reflect more standardized and objective scoring for both patients and clinicians by developing standardized photographs that matched each scoring category. A literature review was undertaken on the esthetic factors within the PES and WES to determine the degree of change that would be clinically relevant.^{23,28,37} Photographs have been used in previous studies to evaluate the PES.^{37,48} For the present study, a set of 1 ideal and 28 altered, life-sized photographs were created to represent scores 0, 1, and 2 (ideal) for scenarios of each of the esthetic factors. More objective descriptions for each of the clinical situations were provided to reduce subjectivity, although objective descriptions for some esthetic factors such as alveolar process and tooth surface texture were not possible

because no measures of these factors were available (Tables 2, 3). One advantage of the current study was the use of photographs to represent real life clinical scenarios.^{15,21,36,39,42} The created photographs provide future users of the AIEI with a visual reference when scoring an anterior implant restoration. Providing a visual reference allows users to compare between 2 different scenarios. This methodology is more objective and will help standardize the way clinicians and researchers score anterior implant-supported restoration esthetic factors.

Ideally, clinicians and researchers should use a standardized esthetic index for more uniform documentation.²⁸ While the PES/WES evaluates esthetic criteria that appears to affect clinician satisfaction, the AIEI was designed to help predict patient satisfaction scores. The AIEI aimed to develop more objective scoring criteria, as well as reference photographs to increase inter- and intra-examiner agreement. Future studies should be undertaken to verify whether the use of these new photographs results in a more reproducible and reliable index. Commitment to a new scoring index based on the importance of each factor in evaluating anterior dental implant esthetics should be developed.

The second aim of the research was to develop a new scoring system that would improve the evaluation of patient satisfaction with anterior implant-supported restorations. Based on the results of this study, some changes to the PES/WES are recommended to better predict patient satisfaction. A new AIEI eliminated esthetic factors that had no effect on patient satisfaction and emphasized factors that heavily influenced patient satisfaction. The eliminated 5 factors were alveolar process, soft tissue texture, soft tissue contour, tooth texture, and tooth form wide; they had no significant measurable bearing on satisfaction and were not considered when configuring the AIEI (Tables 2, 3). While the PES/WES may be useful for determining clinician satisfaction and research documentation, the new AIEI is designed to predict patient satisfaction with anterior implant restorations (Table 3).

Table 2. Summary of esthetic factors with statistically significant difference in satisfaction scores between the score of 0, 1, and ideal photographs

Esthetic Factors in Order of Importance	Esthetic Factor	Participant's Mean Satisfaction Scores / Percentage of 77		
		Score 0 Photograph (%)	Score 1 Photograph (%)	Ideal Photograph (%)
1	Tooth color	24/31	57/74	77/100
2	Mesial papilla	27/35	36/47	77/100
3	Distal papilla	32/42	37/48	77/100
4	Soft tissue color	21/27	23/30	77/100
5	Soft tissue margin	21/27	63/82	77/100
6	Tooth translucency/value- high	41/53	63/82	77/100
7	Tooth translucency/value- low	52/68	67/87	77/100
8	Tooth outline volume	47/61	70/91	77/100
9	Tooth form narrow	60/78	72/94	77/100

Ideal photographs denoted as score of 2. Scores expressed as percentage of 77 (satisfaction score of ideal photo).

Table 3. Anterior Implant Esthetic Index (AIEI) in table format

Esthetic Factors in Order of Importance	Esthetic Factor	Score 0 Photograph	Score 1 Photograph	Ideal Photograph
1	Tooth color	0	2	4
2	Mesial papilla	0		2
3	Distal papilla	0		2
4	Soft tissue color	0		2
5	Soft tissue margin	0	2	
6	Tooth translucency/value- high	0	2	
7	Tooth translucency/value- low	1	2	
8	Tooth outline volume	1	2	
9	Tooth form narrow	1	2	

The scoring used in configuring the AIEI is slightly different from that used for the PES/WES. The present study showed that tooth color was the only factor that had significantly different satisfaction scores between all 3 scoring photographs (Table 2). This suggested that patients were most perceptive to this esthetic factor because any degree of change in deficiency elicited a statistically significant drop in patient satisfaction scores; thus, tooth color had a dose-dependent effect on patient satisfaction scores. It can be concluded that this esthetic factor is the most important to patients and is more heavily weighted in the AIEI (Table 3). Any implant restoration that has a tooth color match similar to or better than the ideal photograph is given a score of 4 on the AIEI. A reasonable approximation is given a score of 2, while a tooth color that is not acceptable is given a score of 0.

The 3 factors with significantly decreased satisfaction scores when photographs in either the 0 and 1 category were illustrated were mesial papilla, distal papilla, and soft tissue color (Table 2). This indicated that patients were not able to tolerate any deficiencies in these factors from the ideal. The ideal thus generated 2 points, while those of categories 0 and 1 garnered 0 points in the AIEI. The observed effect on patient satisfaction scores appears to be an all-or-nothing response, where any deficiency is a concern for the patient; thus, anything less than ideal is not satisfactory (Table 3).

Another 5 factors saw satisfaction scores decrease significantly with a score of 0 but were close between the ideal (2) and a score of 1 (Table 2). These were soft tissue margin, tooth outline volume, tooth translucency high/value low, tooth narrow, and tooth translucency low/value high. This finding suggested that patients were able to tolerate minor deficiencies in these esthetic factors as represented in the score 1 photograph; however, major deficiencies shown as score 0 resulted in a statistically significant decrease in satisfaction. For soft tissue margin and tooth translucency high/value low, the 0 photographs were less than 60% of the satisfaction score given for the ideal photograph. Therefore, a score of 0 should be given if the restoration is deficient below the category 1 level, and a score of 2 was given to levels

1 or 2 (ideal) (Table 3). For tooth outline, tooth narrow, and tooth translucency low/value high, the mean patient satisfaction score for the 0 photographs was 60% to 80% of the satisfaction score given to the ideal photograph. Therefore, a score of 1 was given if the restoration was lower than that of the score 1 photograph, while a 2 was given to anything at the 1 or 2 (ideal) score level (Table 3).

The maximum AIEI score that a restoration can achieve would be 20 points (Table 3). The highest satisfaction score of 77 was given to the ideal photograph by participants. In the new scoring system of the AIEI, score 0 was given when satisfaction scores were less than 60% of 77. A score of 1 was given when satisfaction scores were 60% to 80% of 77. A score of 2 (8 of 9 categories) or 4 (tooth color) was given when satisfaction scores were 80% to 100% of 77. The mean patient satisfaction scores given for the 9 esthetic factors and how they related to each other are summarized in Table 2. The patient satisfaction scores expressed as a percentage of 77 (using 77 as 100%) are also shown in Table 2). The AIEI is summarized in Table 3, with point values given for each category.

Developing scoring ranges for the AIEI system to categorize results as excellent, good, or unacceptable will be challenging. Ideally, a total score close to 20 points increases the likelihood of a successful implant-supported restoration. This scoring system would be particularly useful during the clinical evaluation step before definitive insertion, allowing for optional changes. Any score below 20 should prompt an evaluation of each component. If minor discrepancies are present in a few categories, the restoration might still be considered a success and fall into the good category. However, if the score drops significantly in one category, the overall prosthesis may be deemed unacceptable. Since many clinicians and researchers use the PES/WES to score anterior implant esthetics,^{8,9,15,21,36,39,42} the criteria should be standardized and clear. This is difficult when many of the esthetic factors are poorly defined and there is no reference to follow.^{10,21,40–42}

One of the limitations of the current study was the sample size of 33 participants. The small sample size, combined with multiple statistical analyses, increased

the chance of a Type 1 error. Similarly, a small sample size also increased the chance of a Type 2 error, which means that significant results could not be detected. Future studies should include a large sample size to evaluate the correlation between the PES/WES and patient satisfaction. Another limitation was the inability to test for any interactions between esthetic factors. Since each altered photograph had only 1 factor changed, the study was unable to determine whether deficiencies in 2 or more esthetic factors could result in an additive or exponential drop in satisfaction scores. Future research could include photographs with several altered esthetic factors and thus test for interactions between esthetic factors. This would allow for a multivariate linear regression analysis and determine a more predictive model. In the current study, photographs included only anterior teeth, and the lips and face were eliminated as distracting factors. The effect of the face and skin tone on the perception of tooth color has been reported.⁴⁹ Future studies could verify this finding and determine whether the presence of the lips or face has any effect on the perception and acceptance of different esthetic factors.

CONCLUSIONS

Based on the findings of this study, the following conclusions were drawn:

1. A photographic representation of each criterion within the PES/WES was developed (AIEI) to help clinicians and patients evaluate anterior dental implant esthetics.
2. A new AIEI was developed and had good validation with patient satisfaction scores.
3. In order of importance, tooth color, mesial papilla, distal papilla, and soft tissue color were the 4 principal factors in determining patient satisfaction scores.
4. Alveolar process, soft tissue contour, soft tissue texture, tooth form wide, and tooth surface texture were the 5 factors that had minimal to no influence on patient satisfaction scores.

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