Single Implant Treatment in Healing Versus Healed Sites of the Anterior Maxilla: An Aesthetic Evaluation

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ABSTRACT

Purpose: The aim was to compare and document in detail the aesthetic outcome of single implant treatment in healing sites (early implant placement) with fully healed sites (conventional implant placement) of the anterior maxilla.

Materials and Methods: A cross-sectional study in patients who had been treated by two periodontists and two prosthodontists in 2006 and 2007 was conducted. Surgical treatment involved standard flap elevation without releasing incisions and restorative procedures included cemented crowns in all patients. Only straightforward single implant treatments using Nobelreplace tapered TiUnite® implants (Nobel Biocare, Göteborg, Sweden) in healing sites (6–8 weeks following tooth extraction) and fully healed sites (≥6 months following tooth extraction) were considered with both neighboring teeth present and without the need for hard and/or soft tissue grafting. The aesthetic outcome was objectively rated using the pink esthetic score (PES) and white esthetic scrore (WES) by a blinded clinician who had not been involved in the treatment. Patients rated aesthetics by means of visual analogue scales.

Results: Twenty-one out of 22 early and 25/27 conventional implant treatments were available for aesthetic evaluation after on average two and a half years of function (range 17–41 months). There were no significant differences for any of the criteria between the treatment concepts. Overall, papillae were most easy to satisfy, whereas alveolar process and tooth color most difficult. A thin-scalloped biotype was associated with low distal papillae ($p = .041$) and alveolar process deficiency ($p = .039$). Twenty-six percent of the cases were aesthetic failures (PES < 8 and/or WES < 6) and 13% showed an (almost) perfect outcome (PES ≥ 12 and WES ≥ 9). The remainder (61%) demonstrated acceptable aesthetics. There was no significant correlation between objective and subjective ratings.

Conclusions: Early and conventional single implant treatment yielded comparable aesthetic outcome. Albeit all treatments had been performed by experienced clinicians and only straightforward cases had been selected, 1 out of 4 cases were aesthetic failures and only a strict minority showed perfection. Research is required on the aesthetic outcome of alternative surgical procedures especially in high-risk patients with a thin-scalloped biotype.

KEY WORDS: conventional, dental implant, early, pink esthetic score, single tooth, white esthetic score

INTRODUCTION

Implant therapy is considered highly predictable and successful for the oral rehabilitation of fully and partially edentulous patients. The classical criteria by Albrektsson and colleagues[1] are widely accepted and used as a

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method to assess success. In spite of multiple modifications,[2–4] the focus of these criteria remained osseointegration and therefore, these may not apply to evaluate aesthetics. However, the latter is more and more becoming the key for success in daily practice. Undoubtedly, this is related to the fact that society is evolving with more demanding patients expecting a restoration to be an exact copy of the original tooth. This evolution may explain the growing interest by the scientific community to document aesthetic aspects of treatment outcome.

Aesthetics is all about harmony and symmetry. Hence, the contralateral natural tooth may be considered the ultimate reference when it comes to single implant treatment in the anterior maxilla. Absolute morphometric disparities in papilla levels, midfacial soft tissue levels, and crown parameters have been used to assess the aesthetic outcome of single implant treatment.[5,6] However, parameters such as midfacial soft tissue contour, alveolar process deficiency, color, texture, tooth form, and translucency also contribute to aesthetics and may not be evaluated as such. As a result, the Implant Crown Aesthetic Index by Meijer and colleagues,[7] the pink esthetic score (PES) by Fürhauser and colleagues,[8] and the white esthetic score (WES) by Belser and colleagues[9] including an ordinal scoring index for all parameters were developed. Given the complexity of aesthetics, these methods may be more complete and therefore superior to assess aesthetic treatment outcome.

To our knowledge, there is only one study documenting the aesthetic outcome of single implant treatment in nonaugmented healed sites of the anterior maxilla using such a scoring method.[10] Since only aspects related to the soft tissues were recorded, even these results may be considered incomplete. Belser and colleagues [9] and Buser and colleagues [11] included data on soft tissues and crowns on single implants installed in healing sites of the anterior maxilla and therefore provide a more complete analysis. In both studies, the procedure included advanced surgery meaning early implant placement and simultaneous guided bone regeneration with vertical releasing incisions. Hitherto, no such data have been reported for early implant placement following standard flap elevation even though this approach is common in clinical practice. Obvious advantages of implant placement in the early stages of post-extraction healing include time gain and potentially superior aesthetics since hard and soft tissues have not fully remodeled yet. At least with respect to the midfacial soft tissue level, Schropp and colleagues[12] described an acceptable clinical crown length in significantly more cases following early placement when compared with conventional placement. Gotfredsen[13] described a similar trend. Given the lack of comparative studies with thorough aesthetic analyses by clinicians and patients as pointed out in a recent systematic review,[14] it remains unclear whether single implant placement in healing sites of the anterior maxilla yields superior aesthetic treatment outcome when compared with healed sites. Hence, the purpose of the present study was to compare and document in detail the aesthetic outcome of single implant treatment in healing sites (early implant placement) with fully healed sites (conventional implant placement) of the anterior maxilla. The research hypothesis was that early implant placement would show superior aesthetic treatment outcome when compared with conventional implant placement.[12,13]

MATERIALS AND METHODS

Patient Selection

This study was based on data from patients who had been treated for single tooth implants in 2006 and 2007. The patients were selected on the basis of the following selection criteria:

1. All surgical and restorative treatments performed by two experienced periodontists, respectively, prosthodontists at the Dental Clinic of the Free University in Brussels (VUB) or private practice.
2. Early (6–8 weeks following tooth removal) or conventional (at least 6 months following tooth removal) single implant treatment in the anterior maxilla (region 15–25) using Nobelreplace tapered TiUnite® (Nobel Biocare, Göteborg, Sweden) implants.
3. Natural teeth present both mesial and distal to the implant.
4. Willingness to come in for additional evaluation and informed consent.

Implant treatments including hard and/or soft tissue grafting prior to or at the time of implant surgery were excluded. The study was conducted in accordance with the Helsinki declaration of 1975 as revised in 2000 and the protocol was approved by the ethical committee of the University Hospital in Brussels (UZ Brussel).

Surgical Procedure

In all patients, implant surgery was preceded by screening and a comprehensive clinical and radiographic examination. The surgical procedure was identical for early and conventional implant placement and can be found in detail in a previous paper.[15] Briefly, a standard mucoperiosteal flap was elevated. This included a palatally oriented crestal incision extending to the sulcus of both teeth neighboring the edentulous space. Vertical releasing incisions were never performed. All patients received one or more commercially available implants (Nobelreplace tapered TiUnite®) in a correct three-dimensional position principally as described by Buser and colleagues.[16] One-stage surgery was performed in all cases installing small-diameter healing abutments at the time of surgery. Following 3 months of osseointegration, the small-diameter healing abutments were replaced by wider abutments and the patient was referred to the prosthodontist for restorative treatment.

Restorative Procedure

For details on the restorative and technical procedure, we wish to refer to an accompanying paper.[15] Briefly, an open tray impression coping (Nobel Biocare) was attached and a preselected disposable tray (Coe disposible impression tray, GC America, Alsip, IL, USA) was appropriately perforated. The implant impression was made using a polyether impression material (Impregum Penta®, 3M Espe, Seefeld, Germany). The choice of the abutment material (titanium or ceramic) was left to the discretion of the prosthodontist and included the Aesthetic Abutment® or Procera® Abutment (Nobel Biocare). No attempt was made to condition the soft tissues by means of a provisional crown in any of the patients. All restorations were cemented using temporary cement (Temp-Bond NE, Kerr, Scafati, Italy). Oral hygiene instructions were reinforced following installation of the crown.

Calibration

All aesthetic evaluations relating to the soft tissues (pink aesthetics) and implant crowns (white aesthetics) were performed by one clinician who had not been involved in any treatment. This clinician was calibrated prior to the study on the basis of 20 single implant cases. Per case a frontal and occlusal color slide was available and all were scored twice with an interval of 1 week. The 20 cases were also scored by another clinician.

Evaluation of Pink Aesthetics

The PES by Fürhauser and colleagues[8] was used to evaluate the aesthetic outcome of the peri-implant soft tissues. This index includes seven variables: mesial papilla, distal papilla, midfacial level, midfacial contour, alveolar process deficiency, soft tissue color, soft tissue texture. Each parameter is assessed with a 0-1-2 score with 2 being the best and 0 being the worst score. Thus, a maximum score of 14 can be reached. Papillae are evaluated for completeness; the other variables are assessed by comparison with a reference tooth, which is the contralateral tooth for incisor and cuspid replacements and the neighboring premolar for premolar replacements. The authors set the threshold for clinical acceptance at 8/14. A score of 12/14 or more was considered (almost) perfect.

To control for confounding inflicted by disparities in the gingival biotype among the groups, the latter was also scored. Essentially, patients were categorized on the basis of the transparency of the periodontal probe through the gingival margin when probing the buccal sulcus of the central maxillary incisor(s) as earlier described by De Rouck and colleagues.[17]

Evaluation of White Aesthetics

The WES by Belser and colleagues[9] was used to evaluate the aesthetic outcome of the visible part of the implant restoration. This index includes five variables: tooth form, tooth volume, tooth color including the assessment of hue and value, tooth texture, and translucency. Each parameter is assessed with a 0-1-2 score with 2 being the best and 0 being the worst score. Thus, a maximum score of 10 can be reached. All variables are assessed by comparison with a reference tooth, which is the contralateral tooth for incisor and cuspid replacements and the neighboring premolar for premolar replacements. The authors set the threshold for clinical acceptance at 6/10. A score of 9/10 or more was considered (almost) perfect. Besides the WES, all cases were evaluated for metal exposure.

Patient's Pink and White Aesthetic Satisfaction

Patients were asked to give their opinion on the aesthetic treatment outcome based on the two following questions: "how satisfied are you with the aesthetic outcome

of the gums surrounding the crown?" and "how satisfied are you with the aesthetic outcome of the crown?" The level of satisfaction was rated on two 100 mm visual analogue scales resulting in a score between 0 and 100 corresponding to "very poor aesthetics" and "excellent aesthetics," respectively.

Statistical Analysis

The implant was used as the statistical unit in all analyses. Intra-examiner repeatability and inter-examiner reproducibility on the seven criteria of the PES and the five criteria of the WES were calculated using κ statistics. The Fisher's exact test was adopted to compare the distribution of all criteria of the PES, all criteria of the WES, and the gingival biotype between early and conventional implant placement. The Mann-Whitney test was used to compare the PES, WES, and patient satisfaction scores between early and conventional implant placement. The Spearman correlation coefficient was used to assess association between objective data (PES and WES) and patient satisfaction scores. The impact of the following factors on the seven criteria of the PES was assessed using the Fisher's exact test: reason for tooth loss (periodontitis vs other reasons), gingival biotype (thin-scalloped biotype vs thick biotypes), implant location (central incisor, lateral incisor, cuspid, premolar), implant diameter (small, regular, wide), peri-implant plaque and bleeding, probing depth and bone level as determined by the distance from the implant-abutment junction to the first visible bone-to-implant contact. For this purpose, interval-scaled parameters (probing depth, bone level) were transformed into a binary variable ($0 <$ mean; $1 \geq$ mean). The influence of all factors on the PES was determined using the Mann-Whitney test. The level of significance was set at 0.05.

RESULTS

From the 48 patients who met the selection criteria, 44 (19 men, 25 women; mean age 52; age range 23–76) agreed to come in for evaluation relating to 22 early and 27 conventional implant placements. The mean time from surgery to evaluation was 30 months (SD 9; range 17–41) and 31 months (SD 8; range 18–41) for early and conventionally installed implants, respectively. Twenty-one out of 22 early implant treatments could be aesthetically evaluated since one implant had failed in the early stages of healing. For the same reason, 25/27 conventional implant treatments were available for scrutiny. Thus, the overall implant survival rate was 94%. The overall mean distance from the implant-abutment interface to the first bone-to-implant contact was 1.12 mm (SD 0.60; range 0.00–2.40). All but two crowns were metal-ceramic restorations. The two full-ceramic restorations were connected onto implants installed in fully healed bone. For details on the reasons for tooth loss, implant locations, implant dimensions, clinical outcome, radiographical outcome, and occurrence of complications, we wish to refer to an accompanying paper.[15]

Calibration

All dissimilarities in scoring concerned one unit disparities. Duplicate scoring for the criteria of the PES resulted in moderate to substantial intra-examiner repeatability as defined by Landis and Koch[18] on the basis of κ ranging from 0.404 ($p = .019$) (soft tissue color) to 0.763 ($p < .001$) (mesial papilla). Inter-examiner reproducibility was fair to substantial with κ ranging from 0.389 ($p = .009$) (soft tissue color) to 0.665 ($p < .001$) (distal papilla).

Fair to substantial intra-examiner repeatability was also found for the criteria of the WES. Tooth volume showed the lowest κ (0.360 ($p = .022$)) whereas tooth texture the highest (0.733 ($p = .001$)). Inter-examiner reproducibility showed a κ range from 0.396 ($p = .012$) (tooth color) to 0.625 ($p = .005$) (tooth texture).

Pink Aesthetics and Patient's Pink Aesthetic Satisfaction

Table 1 shows the results of all seven criteria of the PES for early versus conventionally installed implants. There were no significant differences for any of the parameters between the treatment modalities ($p \geq .133$). The presence of papillae was most predictable indicating complete papillae in about 60% of all cases. Unfavorable results were most prevalent for the alveolar process showing severe deficiency in 22% of all cases.

The mean PES was 9.90 (SD 1.92; range 7–13) and 10.40 (SD 2.16; range 6–14) for early and conventionally installed implants, respectively. The difference was not significant ($p = .334$). Figure 1 shows the cumulative percent of the PES for early versus conventionally

TABLE 1 Aesthetic Outcome of Single Implant Treatment

	Early Placement ($n = 21$)			Conventional Placement ($n = 25$)				Early and Conventional Placement ($n = 46$)		
	0	1	2	0	1	2	*p* Value	0	1	2
Mesial papilla	1	8	12	1	8	16	0.877	2 (4%)	16 (35%)	28 (61%)
Distal papilla	2	8	11	1	8	16	0.718	3 (6%)	16 (35%)	27 (59%)
Midfacial level	1	9	11	1	9	15	0.878	2 (4%)	18 (39%)	26 (57%)
Midfacial contour	3	4	14	2	12	11	0.133	5 (11%)	16 (35%)	25 (54%)
Alveolar process deficiency	5	8	8	5	6	14	0.475	10 (22%)	14 (30%)	22 (48%)
Soft tissue color	0	11	10	1	11	13	0.874	1 (2%)	22 (48%)	23 (50%)
Soft tissue texture	1	12	8	1	12	12	0.775	2 (4%)	24 (52%)	20 (44%)
Pink esthetic score Mean (SD)		9.90 (1.92)			10.40 (2.16)		0.334		10.17 (2.05)	
Tooth form	2	5	14	0	9	16	0.306	2 (4%)	14 (31%)	30 (65%)
Tooth volume	3	5	13	1	8	16	0.484	4 (9%)	13 (28%)	29 (63%)
Tooth color	2	13	6	2	10	13	0.271	4 (9%)	23 (50%)	19 (41%)
Tooth texture	0	2	19	0	6	19	0.260	0 (0%)	8 (17%)	38 (83%)
Translucency	2	2	17	2	8	15	0.197	4 (9%)	10 (22%)	32 (69%)
White esthetic score Mean (SD)		7.86 (1.91)			7.96 (1.99)		0.796		7.91 (1.93)	

installed implants. Dotted lines indicate the upper limit for an unacceptable result (PES = 7) and a favorable, yet imperfect result (PES = 11). Fifteen percent of all cases showed an unfavorable outcome and 33% an (almost) perfect result.

The mean patient's pink aesthetic satisfaction was 93% (SD 6; range 80–100) and 91% (SD 8; 70–100) for early and conventionally installed implants, respectively. The difference was not significant ($p = .545$).

There was no significant correlation between the PES and the patient's pink aesthetic satisfaction (Spearman correlation coefficient: 0.212; $p = .162$).

There was no confounding inflicted by disparities in the gingival biotype. 6/21 early implant placements and 11/25 conventional implant placements had been performed in patients with a thin-scalloped biotype ($p = .363$).

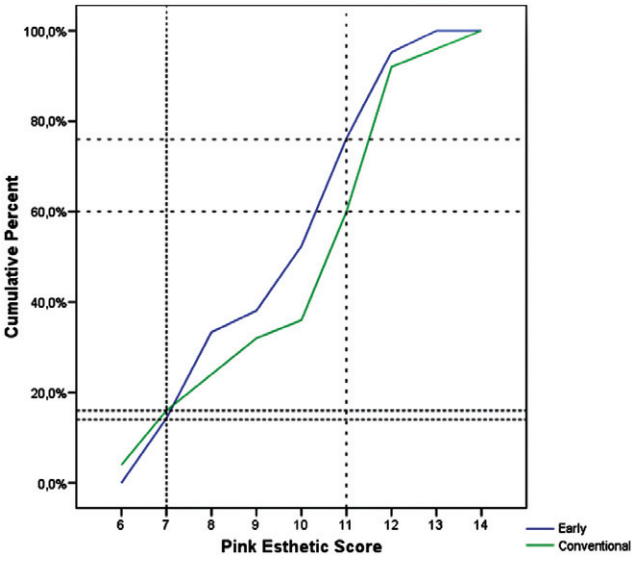

Figure 1 Cumulative percent of the pink esthetic score (PES) for early and conventional single implant treatment.

Factors Associated with Pink Aesthetics

Eleven out of 46 teeth were lost because of periodontal disease. Single implant treatment in these patients showed significantly lower mesial ($p = .001$) and distal ($p = .005$) papillae when compared with implant therapy at sites where the tooth had been lost for other reasons (Figure 2).

Seventeen out of 46 implant treatments had been performed in patients with a thin-scalloped biotype. A thin-scalloped biotype was significantly associated with lower distal papillae ($p = .041$) and severe alveolar process deficiency ($p = .039$).

Nine out of 46 implants were in a central incisor position, 9/46 in a lateral incisor position, 4/46 in a

Figure 2 Implant restoration in the lateral incisor position. The tooth was lost because of periodontal disease. Note advanced mesial papilla loss and the attention for individual traits in the restoration (PES = 9, WES = 8).

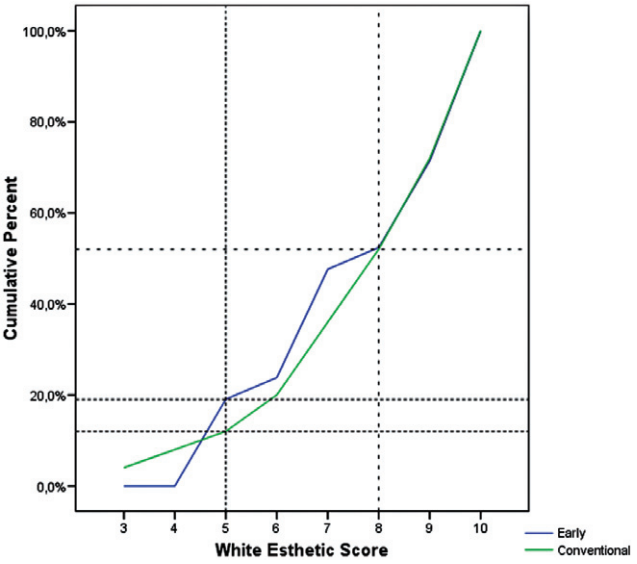

Figure 3 Cumulative percent of the white esthetic score (WES) for early and conventional single implant treatment.

cuspid position, and 24/46 in a premolar position. Implant location was significantly related to the midfacial soft tissue level ($p = .009$). That is, the soft tissue margin was more apically located in relation to the contralateral tooth site at implants in a central incisor position when compared with implants in a lateral incisor position ($p = .015$), cuspid position ($p = .007$), or premolar position ($p = .021$).

Implant diameter, peri-implant plaque and bleeding, probing depth, and bone level were not significantly related to criteria of the PES. The PES was not influenced by any of the factors included in the analyses.

White Aesthetics and Patient's White Aesthetic Satisfaction

Table 1 shows the results of all five criteria of the WES for early versus conventionally installed implants. There were no significant differences for any of the parameters between the treatment modalities ($p \geq .197$). The tooth texture was most predictable indicating an ideal result in 83% of all cases. Unfavorable results were most prevalent for tooth color with a severe mismatch in 9% of all cases and a perfect result in only 41% of all cases.

The mean WES was 7.86 (SD 1.91; range 5–10) and 7.96 (SD 1.99; range 3–10) for early and conventionally installed implants, respectively. The difference was not significant ($p = .796$). Figure 3 shows the cumulative percent of the WES for early versus conventionally installed implants. Dotted lines indicate the upper limit for an unacceptable result (WES = 5) and a favorable, yet imperfect result (WES = 8). Fifteen percent of all cases showed an unfavorable outcome and 59% an (almost) perfect result. Metal exposure was observed in one case.

The mean patient's white aesthetic satisfaction was 94% (SD 6; range 80–100) for both treatment modalities ($p = .734$).

There was no significant correlation between the WES and the patient's white aesthetic satisfaction (Spearman correlation coefficient: 0.161; $p = .322$).

Overall Aesthetic Treatment Outcome

The overall aesthetic treatment outcome was assessed by combining the results of the PES and WES. Six out of 46 (13%) single implant treatments showed an (almost) perfect result (PES ≥ 12 and WES ≥ 9) (Figures 4 and 5). An acceptable result was found for 28/46 (61%) single implant cases (Figure 6). The aesthetic outcome was unfavorable for 12/46 (26%) single implant treatments. Five of them (11%) were considered unfavorable because of a PES < 8, another five (11%) because of a WES < 6. Two single implant treatments (4%) showed a PES < 8 and WES < 6 and could be regarded as complete aesthetic failures. One is illustrated in Figure 5.

DISCUSSION

In this study, two indexes were used to assess the aesthetic outcome of single implant treatment. These are based on objective criteria relating to the soft tissues as well as the implant crown and may therefore provide complete

Figure 4 Implant restoration in the lateral incisor position. Note the perfect soft tissue appearance and restoration (PES = 14, WES = 10).

Figure 6 Implant restoration in the second premolar position. Note advanced mesial and distal papilla loss and the individual characteristics in the restoration (PES = 10, WES = 8).

information on aesthetic treatment outcome. With respect to the PES, papillae appeared most easily reproduced in this study, which is in accordance with Fürhauser and colleagues.[8] The lowest level of agreement was found for soft tissue color and is also supported by Fürhauser and colleagues[8] showing high standard deviation for this parameter following duplicate scoring. To our knowledge, reproducibility data on the WES have never been reported. In our study, the results on tooth texture were most accurate, which could be explained by the fact that this parameter showed an ideal result in the vast majority of the cases. In this respect, tooth volume and especially tooth color may be more difficult to satisfy and may explain the lower levels of agreement. However, all disparities related to one-unit differences indicative of limited variation in the aesthetic perception.

Figure 5 Implant restoration in the cuspid and second premolar position. Note the perfect soft tissue appearance and restoration in the cuspid position (PES = 12, WES = 10) and the complete aesthetic failure with even some metal exposure in the premolar position (PES = 6, WES = 5).

A number of recent systematic reviews have highlighted the scarcity of quality reports comparing early to conventional single implant treatment.[19–22] Although treatment outcome is comparable for both concepts from a clinical and radiographical point of view as confirmed by one of our recent papers,[15] results are incomplete in terms of aesthetics.[12,13] The present study did not reveal an additional value on any of the included aesthetic criteria for early implant treatment over conventional therapy and therefore our research hypothesis could not be confirmed. In a way, this should not be surprising since animal experiments as well as human studies showed that post-extraction bone remodeling is unaffected even by immediate implant placement.[23,24] Given the similar outcome for early and conventionally installed implants, we scrutinized the overall results. As such, papillae showed the highest score of all soft tissue criteria and were complete in about 60% of all cases. This is in line with findings of Lai and colleagues[10] reporting 6-month data on conventional single implant treatment. However, a recent retrospective study by Belser and colleagues[9] on early implant treatment with a similar follow-up as the present study only showed complete distal papillae in less than 30% of the cases. This disparity seems clinically relevant, yet should be interpreted with caution because of the following. First, we documented the aesthetic outcome of single implant treatment following standard flap elevation, whereas Belser and colleagues[9] reported on advanced surgery including vertical releasing incisions and guided bone

regeneration. As shown in one of our reports,[6] low distal papillae may be expected following the latter suggesting an impact of the surgical procedure. Also recent findings by Juodzbalys and Wang[25] support this showing complete papillae in only one-third of the cases treated by immediate implant placement and guided bone regeneration, whereas a recent prospective study contrasts this view.[11] Second, it is impossible to compare the starting point between the studies, which is imperative since the presence of papillae depends upon the bone level at the adjacent tooth.[26–28] As shown by Noelken and colleagues[27] and our data, tooth loss because of periodontal disease is related to papilla levels and may be a reflection of the latter. In this study, about one tooth out of four had been lost because of periodontal disease and could explain the few cases with absent papillae. Finally, it is unclear how many high-risk patients with a thin-scalloped biotype were included in the study by Belser and colleagues.[9] Our data identified the gingival biotype as a significant risk indicator for papilla loss, which is in line with findings of Romeo and colleagues[29] on immediate implants. Over one-third of the cases showed a thin-scalloped biotype in this study as determined by the transparency of the periodontal probe through the gingival margin.[17] The use of an objective method to categorize the gingival biotype is important since simple visual inspection has shown to be unreliable.[15]

In this study, the alveolar process was also related to the gingival biotype and showed the worst results of all soft tissue criteria with severe deficiency in 22% of all cases. This is in accordance with Lai and colleagues[10] reporting on comparable implant treatment. Unfortunately, it is impossible to lift out the results on this parameter in the study by Belser and colleagues[9] since three criteria of the PES had been merged. The combined parameter, however, appeared most difficult [0] to satisfy as confirmed by a prospective study of the same group.[11]

Other relevant soft tissue criteria include midfacial soft tissue level and contour showing an excellent outcome in about half of our cases. These parameters seem easier to control when guided bone regeneration is performed since at least 3 out of 4 cases showed a perfect midfacial level and contour in the study by Belser and colleagues[9] and Buser and colleagues.[11] This may also apply to immediate implants as shown by Juodzbalys and Wang.[25] Comparing other clinical studies with[6] and without[5] guided bone regeneration in terms of midfacial soft tissue level and clinical crown length reveal a similar trend in favor of regenerative therapy.

When considering all soft tissue criteria hereby calculating the PES, 15% of all cases showed an unfavorable outcome and 33% an (almost) perfect result according to our arbitrarily chosen thresholds for clinical acceptance and excellence. These results are slightly better than those reported by Lai and colleagues[10] showing 22% failures and 19% perfection using the same thresholds. Belser and colleagues[9] and Buser and colleagues[11] reported a comparable perfect outcome (22% and 45%, respectively), yet a lower failure rate (≤5%), which could be inflicted by the inclusion of a lot of high-risk patients with periodontitis and/or a thin-scalloped biotype in our study. Interestingly, we found no significant correlation between the PES and the patient's pink aesthetic satisfaction, which contrasts earlier findings by Meijndert and colleagues[30] reporting on the aesthetic outcome of single implant treatment following bone augmentation/regeneration. Possibly, our patients were less critical. On the other hand, these data may be difficult to compare since Meijndert and colleagues[30] used another index to quantify objective ratings.

Only two prosthodontists working together with their dental technician performed all restorative procedures. This was considered imperative since heterogeneity in this respect may result in low WES as shown by Belser and colleagues.[9] Indeed, they described 20% aesthetic failures (WES ≤ 5) and only 18% perfection (WES ≥ 9) when the patient was sent back to the referring dentist for restorative treatment. Based on the same arbitrarily chosen thresholds, 15% of our cases could be considered failures and 48% showed an (almost) perfect outcome, which is in line with Buser and colleagues.[11] As shown in Figures 2 and 6, a lot of attention went to replicating individual traits of the reference tooth. Our data indicated, however, that selecting the appropriate tooth color was difficult and principally responsible for the failures we encountered. As Meijndert and colleagues,[30] we found no significant correlation between objective (WES) and subjective ratings (patient's white aesthetic satisfaction). Also Belser and colleagues[9] and Esposito and colleagues[31] have recently described poor agreement between clinicians and patients in the aesthetic appreciation of implant restorations. Apparently, patients are less critical than clinicians in this respect as described by Chang and coworkers,[32] which may be confirmed by our findings.

Most important is the overall aesthetic outcome combining the results of the PES and WES. As such, only a minority (13%) showed perfection and 1 out of 4 cases were aesthetic failures. Although this failure rate is quite high, it falls within the range of what has been published (5%–34%).[9,11,30] Our failures related to pink aesthetics or white aesthetics and only in a strict minority to both. We believe our findings are relevant as they actually relate to daily clinical practice. As such, retrospective studies may offer a realistic view on what is feasible from day to day.

In this study, the implant was used as the statistical unit. This may be preferred over patient-based analyses since local factors are probably more decisive for aesthetics than patient factors. Figure 5 illustrates this: in one patient an excellent aesthetic outcome was reached for one single implant treatment, whereas a second treatment resulted in complete aesthetic failure. Furthermore, relevant patient factors such as the gingival biotype can always be included in implant-based analyses.

In conclusion, single implant treatment in healing and healed sites of the anterior maxilla yielded comparable results in terms of aesthetics after on average two and a half years of function. Overall, papillae were most easy to satisfy whereas alveolar process and tooth color most difficult. A thin-scalloped biotype was associated with low distal papillae and alveolar process deficiency. Albeit all treatments had been performed by experienced clinicians and only straightforward cases had been selected, 1 out of 4 cases were aesthetic failures and only a strict minority showed perfection. Research is required on the aesthetic outcome of alternative surgical procedures especially in high-risk patients with a thin-scalloped biotype. In addition, data relating to aesthetic aspects of immediate single implants and early/conventional single implants with and without guided bone regeneration performed prior to and at the time of implant surgery are essential. In order to compare the outcome of these modalities, all treatments should be performed by the same clinicians.

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