Soft Tissue Preservation and Pink Aesthetics around Single Immediate Implant Restorations: A 1-Year Prospective Study

Jan Cosyn, DDS, MSc, PhD;[*†] Hugo De Bruyn, DDS, MSc, PhD;[‡] Roberto Cleymaet, DDS, PhD[§]

ABSTRACT

Purpose: (1) To document soft tissue aspects using a specific protocol for immediate implant treatment (IIT) following single-tooth removal; (2) to evaluate whether this protocol allows preservation of pink aesthetics as objectively assessed.

Materials and Methods: Patients with a thick gingival biotype and intact buccal bone wall upon extraction of a single tooth in the aesthetic zone (15–25) were consecutively treated. The protocol included flapless extraction and implant surgery, socket grafting, immediate nonocclusal loading with a screw-retained provisional crown, and replacement by a permanent crown 6 months thereafter. The outcome was assessed after 3, 6, and 12 months. Cases demonstrating major alveolar process remodeling and/or advanced midfacial recession (>1 mm) at 3 months were additionally treated with a connective tissue graft (CTG). The emergence profile of the provisional crown was replicated for all permanent crowns.

Results: Twenty-two patients (12 men, 10 women; mean age 50) were treated after tooth extraction for nonperiodontal reasons using a novel bone condensing implant with variable-thread design, conical connection, and platform switch (NobelActive®, Nobel Biocare, Göteborg, Sweden). One implant failed and mean marginal bone loss was 0.1 mm ($p = .059$). Temporary mesial papilla reduction occurred, whereas distal papilla reduction was permanent (mean 0.5 mm; $p = .001$). At 3 months, five cases demonstrated major alveolar process remodeling and two advanced midfacial recession. Hence, slight initial decline in the pink esthetic score (PES) ($p = .053$) was observed. CTG resulted in a steady improvement of the PES after 3 months ($p \leq .037$). At 12 months, pink aesthetics (mean PES 12.15) was comparable to the preoperative status (mean PES 11.86; $p = .293$). Distal papillae had significantly deteriorated ($p = .020$) in this time span, whereas midfacial contour had significantly improved ($p = .005$).

Conclusions: Preservation of pink aesthetics is possible following IIT. However, to achieve that, CTG may be necessary in about one-third of the patients. Major alveolar process remodeling is the main reason for additional treatment.

KEY WORDS: dental implant, immediate, maxilla, pink esthetic score, single tooth, white esthetic score

INTRODUCTION

Immediate implant treatment (IIT) has become an alluring concept in contemporary practice for obvious reasons of instant reestablishment of function and aesthetics. However, proper risk assessment addressing diagnostic, surgical, and restorative aspects seems mandatory to avoid advanced midfacial recession. Crucial inclusion criteria for a predictable outcome comprise an intact buccal bone wall[1] and a thick gingival biotype.[2,3] Equally important may be a correct three-dimensional implant positioning, which may be hampered by the alveolar socket. Therefore, IIT requires highly

*Periodontist, University of Ghent, Faculty of Medicine and Health Sciences, Dental School, Department of Periodontology and Oral Implantology, De Pintelaan 185, B-9000 Ghent, Belgium; †periodontist, visiting professor, Free University of Brussels (VUB), Faculty of Medicine and Pharmacy, Dental Medicine, Laarbeeklaan 103, B-1090 Brussels, Belgium; ‡periodontist, professor, University of Ghent, Faculty of Medicine and Health Sciences, Dental School, Department of Periodontology and Oral Implantology, De Pintelaan 185, B-9000 Ghent, Belgium; §prosthodontist, professor, Free University of Brussels (VUB), Faculty of Medicine and Pharmacy, Dental Medicine, Laarbeeklaan 103, B-1090 Brussels, Belgium

Reprint requests: Dr. Jan Cosyn, University of Ghent, Faculty of Medicine and Health Sciences, Dental School, Department of Periodontology and Oral Implantology, De Pintelaan 185, B-9000 Ghent, Belgium; e-mail: jan.cosyn@ugent.be

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experienced and skilled surgeons.[4,5] Flapless implant surgery may be another key factor to limit midfacial recession.[6–9] Finally, evidence from a randomized-controlled study[10] and four prospective case series[2,7,9,11] support a preserving effect of an immediate implant crown on midfacial mucosa level. In contrast to aforementioned aspects, controversial results have been published on the need for socket grafting[6–9] and the use of implants with a conical connection and platform switch[7,12] to limit midfacial recession. Consensus is also lacking on the need for soft tissue augmentation following IIT, even though some studies have shown promising results.[13–15]

The above demonstrates that the amount of midfacial recession following IIT is multifactorial. Logically, maximal soft tissue preservation and thus optimal aesthetics would be expected when all factors involved are controlled for. To our knowledge, however, there are no prospective studies available that document soft tissue aspects of such a stringent treatment protocol.

There is a growing interest by scientists for soft tissue dynamics, aesthetic ratings, and patient-centered outcomes of single-implant treatment, which may be a logic consequence of an evolving society focusing on these aspects. Even though favorable aesthetics have been demonstrated following IIT,[9,11] there are obvious limitations to these studies as the aesthetic outcome was only assessed at one point in time. To our knowledge, only one study was published with objective aesthetics ratings at two time points.[16] However, baseline registration was performed after installation of the implant crown and not when the failing tooth was still in situ. As the latter is obviously the ultimate reference, it is currently unclear whether aesthetics may be preserved after single-implant treatment.

The primary objective of this prospective study was to document soft tissue aspects of a stringent protocol for single IIT. A secondary objective was to evaluate whether this protocol allows preservation of pink aesthetics as objectively assessed.

MATERIALS AND METHODS

Patient Selection

This prospective study was based on data from patients who had been treated with a single immediate implant in a private practice. Patients were selected during a screening visit on the basis of inclusion and exclusion criteria.

Inclusion criteria were as follows:

1. at least 18 years old;
2. good oral hygiene defined as full-mouth plaque score ≤25%[17];
3. presence of a single failing tooth in the anterior maxilla (15–25) with both neighboring teeth present;
4. ideal soft tissue level/contour at the facial aspect of the failing tooth in perfect harmony with the surrounding teeth;
5. thick gingival biotype as determined by De Rouck and colleagues[18];
6. adequate bone height apical to the alveolus of the failing tooth (≥5 mm) to ensure primary implant stability of at least 35 Ncm;
7. signed informed consent.

Exclusion criteria were as follows:

1. systemic diseases;
2. smoking;
3. bruxism, lack of posterior occlusion;
4. periodontal disease or history of periodontal disease;
5. presence of active infection (pus, fistula) around the failing tooth;
6. loss of the buccal bone crest after extraction of the failing tooth.

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).

Flapless Surgery, Socket Grafting, and Provisional Restoration

Implant surgery was preceded by antibiotic therapy (amoxicillin 1,000 mg twice a day for 4 days and started the day before) and oral disinfection (Corsodyl®, GlaxoSmithKline, Genval, Belgium). Teeth scheduled for immediate replacement were removed without flap elevation. Periotomes were used to minimize tissue trauma. Immediate implant placement (NobelActive®, Nobel Biocare, Göteborg, Sweden) was performed if the buccal bone crest was intact. Special attention was paid to a correct selection and three-dimensional positioning of the implant as described by Buser and colleagues.[19] Following the confirmation of the primary stability (≥35 Ncm) using a torque controller, implant

impression was made for a screw-retained provisional crown that was installed approximately 3 hours following the surgery. Deproteinized bovine bone particles (Bio-Oss® 0.25–1 mm, Geistlich Biomaterials, Wolhusen, Switzerland) soaked in blood were inserted to fill the void between the implant and alveolar socket. An appropriate healing abutment was applied until the provisional restoration was installed. The latter was fabricated in the dental laboratory by means of an engaging titanium temporary abutment serving as a carrier for an appropriate hollowed denture tooth. The provisional restoration was tightened at 15 Ncm and adjusted to clear centric and excentric contacts in order to avoid full functional load. Aforementioned procedures were performed by the same doctor (J.C.).

Connective Tissue Graft

Three months following implant surgery, a first reassessment was performed. In case of major alveolar process remodeling and/or advanced midfacial recession (>1 mm), additional treatment was deemed required. In this context, any major alveolar process defect after 3 months as defined by Fürhauser and colleagues[20] (ordinal index with a 0-1-2 score with 0 being the poorest score indicating a major defect and 0 being the best score indicating no defect) was considered the result of major alveolar process remodeling given the fact that the alveolar process was intact at the time of tooth removal. Additional treatment included a connective tissue graft (CTG) harvested from the palate and inserted in the buccal peri-implant mucosa via the envelope (pouch) technique (Figure 1). Single 6/0 sutures (Seralon® Serag Wiessner, Nail, Germany) were applied to immobilize the graft in the appropriate position. Prior to CTG fixation, the transmucosal buccal aspect of the provisional restoration was made concave to avoid soft tissue pressure and to allow for in/upgrowth. These procedures were performed by the same doctor (J.C.).

Replication of Emergence Profile and Permanent Restoration

Six months following implant surgery, a second reassessment was performed. Thereupon, clinical procedures were initiated for fabrication of the permanent restoration. Attention was paid to an accurate replication of the emergence profile that had been created by the provisional restoration (Figure 2). First, the provisional restoration was connected onto an implant replica and embedded in silicon paste (Optosil® Comfort Putty, Heraeus Kulzer GmbH, Hanau, Germany). Then, the provisional restoration was replaced by an open tray impression coping. The void between the silicon and impression coping was filled with autopolymerizing acrylic resin (TAB 2000®, Kerr, Orange, CA, USA). This individualized impression coping was used to make the final implant impression. That part of the individualized coping facing the peri-implant tissues was colored in black to evaluate transparency through the soft tissues. In case of apparent transparency, a full-ceramic crown (Procera®, Nobel Biocare) was advised instead of a metal-ceramic crown. Permanent restorations were screw-retained or cemented. For cemented crowns, temporary cement (Temp-Bond NE®, Kerr, Scafati, Italy) was used. All restorative procedures were performed by the same prosthodontist (R.C.) and all permanent restorations were fabricated in the same dental laboratory.

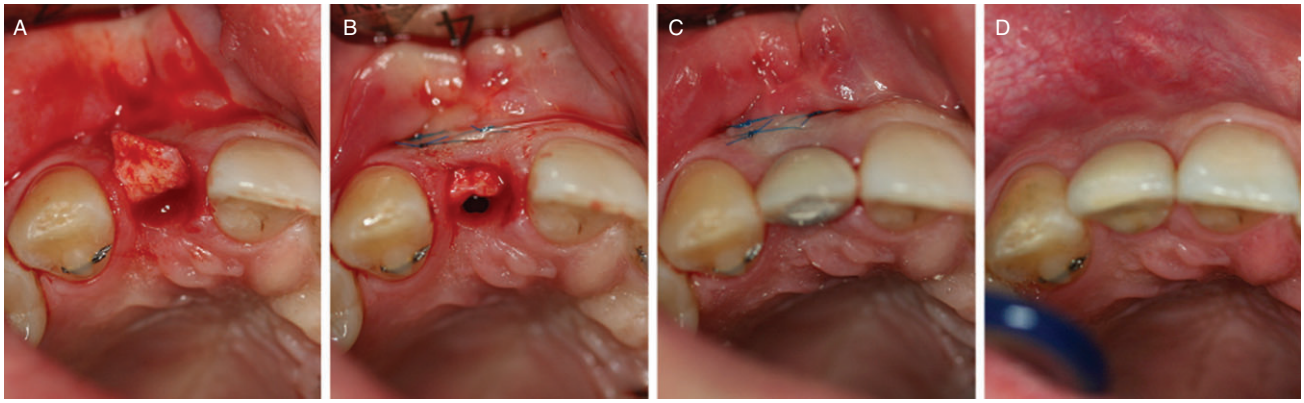

Figure 1 Connective tissue graft. Intrasulcular incision and insertion of connective tissue graft (A), fixation of connective tissue graft via monofilament sutures (B), provisional restoration in situ (C), and permanent restoration in situ (D).

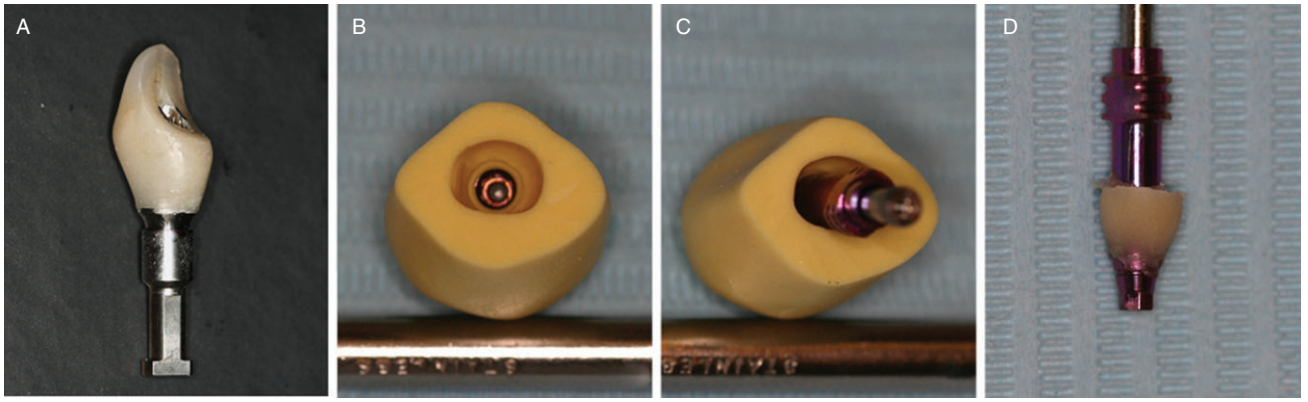

Figure 2 Replication of emergence profile. Connection of the provisional restoration onto an implant replica (A), replicated emergence profile by embedding the provisional restoration and implant replica in silicon paste (B), connection of an open tray impression coping onto the implant replica (C), and individualized impression coping by filling the void between the silicon and open tray impression coping (D).

Implant Survival and Complications

Three, 6, and 12 months following implant surgery, patients were evaluated for implant survival and complications. The latter included biologic (abscess and fistula), technical (loosening of the abutment screw, loss of retention of the crown, and fracture of components), as well as aesthetic (major alveolar process remodeling and advanced midfacial recession [>1 mm]) complications.

Marginal Bone Loss

Immediately following implant installation and after 3, 6, and 12 months, a digital periapical radiograph was made using the long-cone paralleling technique. Bone level was defined as the distance from the implant-abutment interface to the first bone-to-implant contact and was calculated for each implant (mean of mesial and distal side) and for each time point using designated software (DBSWIN, Dürr Dental AG, Bietigheim-Bissingen, Germany). Bone coronal to the interface was set to zero. Bone loss was calculated for each follow-up time point (3, 6, and 12 months with respect to implant installation) by the same clinician (J.C.). Bone loss at 3 months was also calculated by another clinician (R.C.) to evaluate interassessor agreement.

Soft Tissue Parameters

After 12 months, the *clinical conditions* of the implant restoration and its contralateral tooth were evaluated by means of the following parameters:

1. *Plaque score.* A dichotomous score was given (0 = no visible plaque at the soft tissue margin; 1 = visible plaque at the soft tissue margin) at four sites (mesial, midfacial, distal, and palatal).
2. *Probing depth.* It was measured to the nearest 0.5 mm at four sites (mesial, midfacial, distal, and palatal) using a manual probe (CP 15 UNC, Hu-Friedy®, Chicago, IL, USA).
3. *Bleeding on probing.* A dichotomous score was given (0 = no bleeding; 1 = bleeding) at four sites (mesial, midfacial, distal, and palatal).

Soft tissue dimensions were measured when the failing tooth was still in situ and after 3, 6, and 12 months following implant surgery by means of the following parameters:

1. *Papilla reduction.* Papilla level was recorded by means of an acrylic stent provided with direction grooves and defined as the distance from the top of the groove to the top of the mesial or distal papilla measured to the nearest 0.5 mm using a manual probe (CP 15 UNC, Hu-Friedy).[21] Papilla reduction was calculated for each follow-up time point (3, 6, and 12 months with respect to the preoperative status).
2. *Midfacial recession.* Midfacial mucosa level was measured using the same acrylic stent provided with a central direction groove and defined as the distance from the top of the groove to the zenith of the restoration measured to the nearest 0.5 mm using a manual probe (CP 15 UNC, Hu-Friedy).[20] Midfacial recession was calculated for each follow-up time point (3, 6, and 12 months with respect to the preoperative status).

The same clinician performed all measurements on soft tissue dimensions (J.C.).

Aesthetic Outcome

Aesthetic aspects of treatment outcome were rated by the same calibrated clinician (J.C.). Calibration was performed prior to the study and was based on color slides of 20 single-implant cases in the anterior maxilla. The results on interassessor agreement can be found in a recent paper.[22]

The *pink esthetic score* (PES) by Fürhauser and colleagues[20] 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, and 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 *white esthetic score* (WES) by Belser and colleagues[23] 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. Again, 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.

Statistical Analysis

Data analysis was performed using the patient as the experimental unit. Interassessor agreement on marginal bone loss was evaluated using percentage agreement within 0.1-mm deviation, Spearman correlation coefficient, and Wilcoxon signed-rank test. Descriptive statistics on the outcome variables included mean values where applicable and frequency distributions. Changes over time were evaluated using the Friedman test. If the latter demonstrated a significant time effect, Wilcoxon signed-rank tests were performed to compare time points pairwise. The same test was applied to compare clinical conditions of implant restorations with contralateral teeth. The impact of the restoration material (full-ceramic vs metal-ceramic crown) on the criteria of the WES was examined using the Fisher's exact test. Full-ceramic and metal-ceramic crowns were compared in terms of the WES by means of the Mann-Whitney test. The level of significance was set at 0.05 with no corrections for multiple comparisons.

RESULTS

Twenty-two patients were consecutively treated between January 2009 and April 2010 (12 men, 10 women; mean age of 50 with a range from 27 to 74) with a single immediate implant in the aesthetic zone. Eleven teeth were removed because of root fracture, nine because of caries and sequels, and two as a result of root resorption. Eleven teeth were in a central incisor position, six in a lateral incisor position, four in a premolar position, and one in a cuspid position. One patient dropped out after 6 months. She was contacted by phone but was not able to return for reassessment. Another patient still had the provisional crown at 12 months. Seven patients were treated with a full-ceramic crown and 12 with a metal-ceramic crown. Permanent crowns were screw-retained in nine patients and cemented in 10 patients.

Implant Survival and Complications

Eleven out of 22 implants were inserted with high insertion torque (50–70 Ncm). Table 1 shows implant survival and complications. Two weeks following surgery, one implant had to be removed because of pain and mobility (central incisor position; diameter 4.3 mm – length 15 mm). Besides this one early failure, all implants remained well integrated. With respect to complications, one provisional crown lost retention after 1 month and another broke after 2 months. In another case, the denture tooth was found detached from the temporary abutment. Besides these technical complications, seven patients demonstrated aesthetic complications after 3 months. Five related to major alveolar process remodeling and two related to advanced midfacial recession (>1 mm). CTG was performed in all seven patients to optimize aesthetics.

Marginal Bone Loss

Interassessor agreement on marginal bone loss was favorable (71% agreement within 0.1-mm deviation; Spearman correlation coefficient: 0.876 – $p < .001$;

TABLE 1 Survival, Complications, Marginal Bone Loss, and Soft Tissue Changes of Single Immediate Implants

Parameter	3 Months	6 Months	12 Months	*p* Value
Implant survival	21/22	21/22	20/21	/
Complications	3 technical, 7 aesthetic	None	None	/
Marginal bone loss*	0.1 (0.4) [−1.0; 0.8]	0.1 (0.5) [−1.3; 0.8]	0.1 (0.5) [−1.3; 0.8]	.059
	52% ≤ 0.0-mm bone loss	43% ≤ 0.0-mm bone loss	33% ≤ 0.0-mm bone loss	
	9% > 0.5-mm bone loss	14% > 0.5-mm bone loss	14% > 0.5-mm bone loss	
Mesial papilla reduction*	0.5 (0.7) [−1.0; 1.5]	0.3 (0.6) [−0.5; 1.5]	0.2 (0.5) [−1.0; 1.0]	.004
	5% > 1-mm papilla loss	5% > 1-mm papilla loss	0% > 1-mm papilla loss	
Distal papilla reduction*	0.6 (0.6) [−0.5; 1.5]	0.4 (0.5) [−0.5; 1.5]	0.5 (0.5) [0.0; 1.5]	<.001
	9% > 1-mm papilla loss	5% > 1-mm papilla loss	10% > 1-mm papilla loss	
Midfacial recession*	0.3 (0.8) [−1.5; 2.0]	0.3 (0.5) [−1.0; 1.0]	0.2 (0.4) [−0.5; 1.0]	.056
	9% > 1-mm recession	0% > 1-mm recession	0% > 1-mm recession	

*Mean (standard deviation) [minimum; maximum] in millimeter; positive value indicates reduction or recession; negative value indicates gain or overgrowth.

Wilcoxon signed-rank test: $p = .931$). Table 1 shows marginal bone loss with respect to implant installation after 3, 6, and 12 months. Overall, marginal bone loss was of borderline significance (mean 0.1 mm; $p = .059$). After 12 months, 33% of the implants demonstrated steady levels or bone gain and 14% showed bone loss exceeding 0.5 mm. Maximum bone loss was 0.8 mm. A clinical and radiographic follow-up is presented in Figure 3.

Soft Tissue Parameters

The clinical *conditions* of the implant restorations and contralateral teeth were examined after 12 months. Mean plaque levels were 13% and 19% for implants and teeth, respectively ($p = .025$). Bleeding on probing was significantly higher around implants than around teeth (24% vs 9%; $p = .001$) as was probing depth (3.07 mm vs 2.56 mm; $p = .005$). Maximum probing depth around implants was 5 mm.

Table 1 depicts the *dimensional changes* of the soft tissue outline around the implant restorations in relation to the preoperative status. Overall, mesial papilla reduction was significant ($p = .004$) with most shrinkage in the early stages of healing (0.5 mm; $p = .009$). A trend toward regrowth was observed between 3 and 6 months (0.2 mm; $p = .059$). Mesial papilla regained their original height at 12 months ($p = .083$). Hence, there were no cases demonstrating advanced mesial papilla reduction (>1 mm) at the end of the study.

Overall, distal papilla reduction was significant ($p < .001$) with most shrinkage in the early stages of

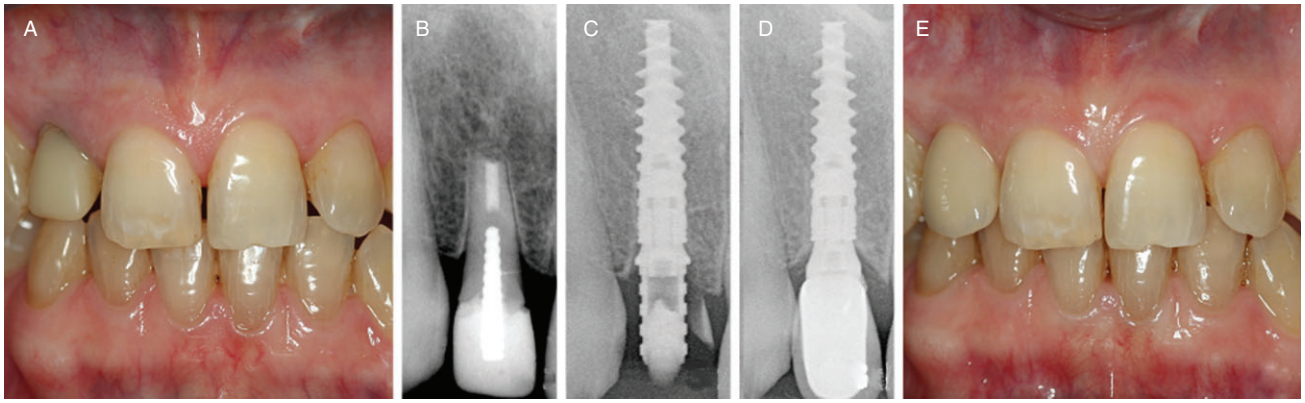

Figure 3 Marginal bone preservation. Starting point with failing tooth 12 in situ (A), periapical radiograph of tooth 12 (B), periapical radiograph of implant 12 and provisional restoration at the day of surgery (C), periapical radiograph of implant 12 and permanent restoration after 12 months demonstrating full bone preservation (D), and final result after 12 months (E).

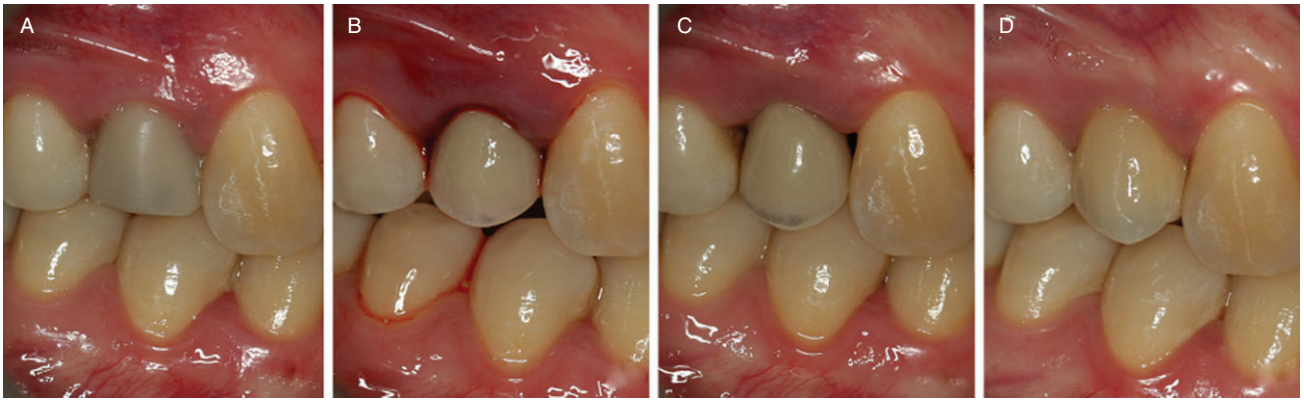

Figure 4 Dimensional changes of the soft tissue outline. Starting point with failing tooth 14 in situ (A), soft tissue outline immediately following installation of the provisional restoration (B), and soft tissue outline after 3 months. Note some papilla loss at the mesial and distal aspect (C), soft tissue outline after 12 months. Note the regrowth of papillae and a stable midfacial mucosa (D).

healing (0.6 mm; $p = .001$). Significant regrowth was observed between 3 and 6 months (0.2 mm; $p = .011$). However, distal papillae did not fully regain their original height at 12 months ($p = .001$). In fact, 10% of the cases demonstrated advanced distal papilla reduction (>1 mm) at the end of the study.

There was no significant midfacial recession over time, albeit the time effect was of borderline significance ($p = .056$). Note that two cases (9%) demonstrated advanced midfacial recession (1.5 and 2 mm) after 3 months. As a result of CTG, midfacial recession could be limited to 0.5 mm in both cases after 6 and 12 months.

A case is shown in Figure 4 illustrating initial papilla reduction, papilla regrowth between 3 and 12 months, and stability of the midfacial mucosa over time.

Aesthetic Outcome

Table 2 shows the results of all seven criteria of the *PES* per time point. Apart from soft tissue color and texture, all criteria showed a significant time effect ($p \leq .021$). Incomplete mesial and distal papillae were significantly more common at 3 months when compared with the preoperative status ($p \leq .021$). However, a trend toward refill of the embrasure space was found between 3 and 6 months at the mesial aspect ($p = .083$) and between 6 and 12 months at the distal aspect ($p = .083$). Midfacial level showed significantly more discrepancy with the corresponding natural tooth at 3 months when compared with the preoperative status ($p = .007$). Mainly due to CTG in the two worst cases, a trend toward improvement could be observed between 3 and 6 months ($p = .059$). Midfacial contour showed significant improvement in the early stages of healing ($p = .025$). Alveolar process deficiency was significantly more common at 3 months when compared with the preoperative status ($p = .025$). Due to CTG in the five worst cases, significant improvement could be observed between 3 and 6 months ($p = .034$).

A significant time effect was found for PES ($p = .005$). In fact, deterioration of borderline significance was demonstrated at 3 months when compared with the preoperative status ($p = .053$). Thereafter, PES improved steadily (3–6 months: $p = .003$; 6–12 months: $p = .037$). As a result, there was no significant difference in the PES between the preoperative status and 12 months ($p = .293$). When scrutinizing the changes between the preoperative status and the end of the study in terms of the seven criteria of the PES, one criterion showed significant deterioration (distal papilla: $p = .020$), whereas one criterion demonstrated significant improvement (midfacial contour: $p = .005$).

At least 15/19 cases demonstrated a score of 2 for all but one criteria of the *WES*. Tooth color was most problematic with one total mismatch and 11 minor discrepancies. Mean WES was 8.63 (SD 1.07; range 7–10). There was no significant difference for any of the criteria of the WES between full-ceramic and metal-ceramic crowns ($p \geq .211$). Also, the WES did not differ significantly between restoration materials ($p = .722$).

DISCUSSION

The present prospective study demonstrated substantial alterations in soft tissue levels during the early healing phase following single IIT. This is quite remarkable given the fact that a strict protocol was used based on maximal hard and soft tissue preservation and immediate soft

TABLE 2 Pink Esthetic Score of Single Immediate Implants

Parameter	Score†	Preoperative (*n* = 22)	3 Months (*n* = 21)	6 Months (*n* = 21)	12 Months (*n* = 20)	*p* Value
Mesial papilla	0	1	0	0	0	.021
	1	6	16	13	10	
	2	15	5	8	10	
Distal papilla	0	0	1	1	1	<.001
	1	7	15	15	11	
	2	15	5	5	8	
Midfacial level	0	0	2	0	0	.003
	1	1	6	5	4	
	2	21	13	16	16	
Midfacial contour	0	2	0	0	0	.006
	1	7	5	3	0	
	2	13	16	18	20	
Alveolar process deficiency	0	0	5	0	0	.003
	1	0	0	1	1	
	2	22	16	20	19	
Soft tissue color	0	1	0	0	1	.312
	1	12	9	8	8	
	2	9	12	13	11	
Soft tissue texture	0	1	2	0	0	.061
	1	4	1	3	0	
	2	17	18	18	20	
Pink esthetic score*		11.86 (1.61) [8; 14]	10.67 (1.65) [8; 13]	11.67 (1.07) [10; 13]	12.15 (0.99) [10; 13]	.005

*Mean (standard deviation) [minimum; maximum].
†0: no discrepancy; 1: minor discrepancy; 2: major discrepancy.

tissue support. Papillae showed spontaneous regeneration especially at the mesial aspect, whereas additional treatment was necessary to overcome major alveolar process remodeling or advanced midfacial recession (>1 mm) in about one-third of the cases. As such, pink aesthetics could be preserved.

In recent years, at least four randomized-controlled studies have been published demonstrating significantly less marginal bone loss for implants with a platform switch when compared with implants with a flat-to-flat connection.[12,24–26] The very limited marginal bone loss (mean 0.1 mm) we observed is in accordance with these studies. Interestingly, this is the first paper that reports on bone loss for this implant system following immediate placement and nonocclusal loading, which may be its key indication. More important in the context of aesthetics, however, is the fact that platform switching implants may show superior soft tissue preservation as demonstrated by one randomized-controlled study.[7] Although the latter may still be controversial,[12] it was in fact another reason for using the implant system in this study.

In a recent study on various modalities of single-implant treatment, tooth loss because of periodontal disease was found a major risk factor for incomplete papillae.[27] As our goal was to evaluate the impact of the treatment protocol on papillae, note that we excluded periodontitis patients in this study. Interestingly, significant papilla reduction occurred in the early stages of healing in spite of the fact that no flap had been raised and an immediate implant crown had been installed, which is in accordance with an earlier report.[28] At 12 months, however, mesial papillae regained their original height, whereas distal papilla reduction was permanent, albeit limited (mean 0.5 mm). Also in other studies, distal papilla preservation showed to be more problematic than mesial papilla preservation without obvious explanation.[7,21,27,29] Adaptation of the final crown emergence profile could be an option to overcome the problem of incomplete distal papillae. On the other

hand, one should take into account the relatively short observation period of the present study. In this respect, Cosyn and colleagues[11] showed that papilla regeneration may take up to 3 years following IIT. As a result, longer follow-up of the present cohort would be valuable to evaluate the time effect on distal papillae.

We observed no relevant midfacial recession over a 12-month time span. However, we performed CTG in two cases showing advanced midfacial recession at 3 months, which could have contributed to this finding. Such additional treatment was conducted quite early following implant installation as the vast majority of soft tissue alterations are to be expected within this time frame.[1,21,30,31] We also provided additional treatment by means of CTG in five other cases demonstrating major alveolar process remodeling at 3 months. As such, the latter may be considered the most common aesthetic complication of the stringent treatment protocol we scrutinized. Note that without additional soft tissue augmentation, a major alveolar process defect also appeared to be a common finding after years of function affecting at least 15% of the cases treated by means of an immediate implant.[11,27]

In this study, it was decided to perform CTG only in selected cases with aesthetic complications. Alternatively, we could have performed CTG in conjunction to IIT in all cases as described by others.[15,32,33] Given these and our findings, systematic CTG at the time of implant installation or selective CTG later on may both result in negligible midfacial soft tissue alterations, at least in the short term. On the other hand, the former could be considered overtreatment as additional surgery could not be justified on the basis of soft tissue ratings in the majority of our patients (14/21). In addition, bone loss may be inevitable when raising a full- or even partial-thickness flap[34] for CTG insertion, and its impact on soft tissue dynamics is yet to be determined in the long term. Also avoiding contamination of the graft by bovine bone particles and possibly cement may be difficult to overcome when CTG is performed at the time of implant installation.

Papilla reduction, midfacial recession, and alveolar process deficiency contributed to a slight deterioration in pink aesthetics (PES) in the early stages of healing. Spontaneous papilla regeneration especially at the mesial aspect and CTG in selected cases resulted in a steady improvement of the PES after 3 months. At 12 months, pink aesthetics (mean PES 12.15) was comparable with the preoperative status (mean PES 11.86) and as such, aesthetics could be preserved. To our knowledge, this is the first study with baseline registration for aesthetic ratings prior to tooth loss, which is the only proper reference to evaluate this aspect of treatment outcome over time. Even though pink aesthetics was comparable between 12 months and the preoperative status, note that distal papillae had significantly deteriorated in this time span, whereas midfacial contour had significantly improved. The latter may be explained by improper contour of six restorations at the buccal aspect of the failing tooth. In comparison to other studies with data on pink aesthetics, mean PES of 12.15 may be considered quite high.[5,9,11,16,21,22,27] However, in contrast to the present investigation, periodontitis patients were never excluded in these studies. Another reason could be that we performed additional treatment by means of CTG in seven patients to optimize aesthetic treatment outcome.

The aesthetic outcome of the implant crown was satisfying (mean WES 8.63) in this study. We observed no impact of the restoration material on the WES or its aspects, which confirms recent findings by Gallucci and colleagues.[35]

In conclusion, this prospective study evaluated a stringent protocol for single IIT. The latter included flapless extraction and implant surgery, socket grafting, immediate nonocclusal loading with a screw-retained provisional crown, and replacement by a permanent crown 6 months thereafter. CTG was performed in case aesthetic complications occurred and the emergence profile of the provisional crown was replicated for all permanent crowns. Papilla reduction, midfacial recession, and alveolar process deficiency contributed to a slight deterioration in pink aesthetics in the early stages of healing. Spontaneous papilla regeneration especially at the mesial aspect and CTG resulted in a steady improvement of the PES after 3 months. At 12 months, the PES was comparable to the preoperative status. These data indicate that preservation of pink aesthetics is possible following IIT. However, to achieve that, CTG may be necessary in about one-third of the patients.

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