Treatment Outcome of Two Adjacent Implant-Supported Restorations with Different Implant Platform Designs in the Esthetic Region: A Five-Year Randomized Clinical Trial

Wouter G. Van Nimwegen, BSc^a/Gerry M. Raghoebar, DDS, MD, PhD^b/Kees Stellingsma, DDS, PhD^c/ Nynke Tymstra, DDS, PhD^d/Arjan Vissink, DDS, MD, PhD^b/Henny J.A. Meijer, DDS, PhD^e

> **Purpose:** The aim of this study was to evaluate the peri-implant soft and hard tissues and satisfaction in patients with two adjacent implant-supported restorations in the esthetic region, treated with two adjacent implants with a scalloped or flat platform. Materials and Methods: The randomized clinical trial consisted of 40 patients allocated to either a scalloped implant group consisting of 20 patients or a flat implant group of 20 patients. Clinical and radiographic examinations were performed during a 5-year followup period, and patient satisfaction during the same period was assessed. **Results:** The scalloped implant group showed significantly more marginal bone loss (scalloped: 3.2 ± 1.1 mm; flat: 1.5 ± 0.8 mm) and significantly greater bone loss at the interimplant bone crest (scalloped: 2.4 ± 1.0 mm; flat: 1.3 ± 1.0 mm). Furthermore, peri-implant soft tissues showed significantly more bleeding when provided with scalloped implants than with flat implants. Papilla index scores were low in both groups. Patient satisfaction was high in both groups. Conclusion: More bone loss and compromised interimplant papilla regeneration were noted around scalloped implants in the first year, and stable results were observed in the subsequent 4 years with both systems. Scalloped implants seem to offer no benefit when compared to conventional flat implants in the esthetic region. Int J Prosthodont 2015;28:490-498. doi: 10.11607/ijp.4199

ong-term research shows promising results for the life span of dental implants in the esthetic region.^{1,2} As failure rates of dental implants have been shown to be low, criteria determining implant success rather than implant survival has become an area of interest in international research.³ These criteria include the establishment of a soft tissue contour with

^dResearch Associate, Private Practice, Ureterp, Netherlands.

^eProfessor, University of Groningen, University Medical Center Groningen, Department of Oral and Maxillofacial Surgery and Department of Prosthetic Dentistry, Dental School, Groningen, Netherlands.

Correspondence to: Prof Dr H.J.A. Meijer, Department of Oral and Maxillofacial Surgery, University Medical Center Groningen, PO Box 30.001, NL-9700 RB, Groningen, Netherlands. Fax: 31-(0)50-3611136. Email: h.j.a.meijer@umcg.nl

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intact papillae and a gingival outline that is harmonious with the gingival silhouette of the adjacent healthy dentition.^{4,5} The preservation of interproximal papillae next to single-tooth implants is presumed to depend predominantly on the level of marginal bone and the attachment level of the neighboring teeth in particular, but a range of other factors that contribute to the presence of papillae, including the gingival biotype, are also mentioned.⁶⁻⁸ This explains why papilla formation between two adjacent implants, where there is no support from marginal bone of neighboring teeth, is rather unpredictable and difficult to achieve. In addition, preoperative bone conditions for adjacent implants are often poor, as many patients have a history of trauma. In these cases, ongoing bone resorption and vertical and horizontal bone deficiencies require augmentation procedures to allow for predictable and reliable implant placement and prosthodontics. When taking these factors into account, placement of two adjacent implant-supported restorations in the esthetic region is considered a treatment with many uncertainties, in particular with regard to achieving satisfactory results in peri-implant hard and soft tissue.9,10

Conventional implant therapy in the esthetic region includes the use of implants with a flat collar. A major issue with the flat implant design is that it is not able

^aResearch Student, University of Groningen, University Medical Center Groningen, Department of Prosthetic Dentistry,

Dental School, Groningen, Netherlands.

^bProfessor, University of Groningen, University Medical Center Groningen, Department of Oral and Maxillofacial Surgery, Groningen, Netherlands.

^cResearch Associate, University of Groningen, University Medical Center Groningen, Department of Oral and Maxillofacial Surgery, Groningen, Netherlands.

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to fully maintain the alveolar bone crest, the interproximal bone peak in particular that exists after extraction of teeth in the esthetic region. The vertical difference between the lower facial alveolar bone crest and the interproximal bone peak has been shown to contribute to the formation of an interproximal papilla. The scalloped implant was launched in 2003 with a new collar design to create or maintain the anatomy of the alveolar bone crest and thereby maintain satisfactory periimplant soft tissue levels and interproximal papillae.¹¹

Until recent years, little research was available on the clinical results of the scalloped implant design. The few articles that were available showed contradictory results. Some studies reported that the interproximal bone crest could be preserved using a scalloped implant design,^{12,13} whereas other studies reported that marginal bone levels were not maintained properly around the scalloped implant design.^{14,15} Furthermore, a study conducted by Nowzari et al¹⁶ reported a significantly greater amount of bone loss around scalloped implants when compared to flat implants. The reported contradictory results demand more research. Den Hartog et al¹⁷ and Tymstra et al¹⁰ conducted research on scalloped implants in the esthetic zone. Both studies showed that scalloped implants had less stable marginal bone levels than flat implants. Furthermore, it seemed that marginal bone levels did not follow the scalloped three-dimensional platform of the scalloped implant design. Moreover, Tymstra et al¹⁰ showed deeper pocket probing depths and more marginal recession of the gingiva around scalloped implants compared to flat implants. Although both studies showed less favorable bone levels around scalloped implants, no significant differences between scalloped and conventional flat implant designs were found regarding peri-implant soft tissues and patient satisfaction. Both studies implicated that scalloped implants offer no clinical advantage compared to flat implants in the short term, but longer evaluation periods are needed to confirm this claim. The present study is a follow-up on the 1-year results of Tymstra et al.¹⁰ The study aims to assess the 5-year clinical (probing depth, plaque, bleeding, gingival health), radiographic (peri-implant bone changes), and patient satisfaction parameters of two adjacent implant restorations in the esthetic region, treated with either a scalloped platform or a conventional flat platform.

Materials and Methods

The patients selected for this study had been referred to the Department of Oral and Maxillofacial Surgery (University Medical Center Groningen, University of Groningen, Netherlands) for implant-based prosthodontic rehabilitation of two adjacent anterior maxillary teeth. Patients were selected on the basis of the following inclusion criteria: missing or lost teeth were an incisor (central or lateral), a canine, or a first premolar in the maxilla; teeth missing were adjacent; the site was healed (it had been at least 3 months since the tooth removal); sufficient bone was available for the placement of two adjacent dental implants (if required, a bone augmentation procedure was performed at least 4 months before implant placement); sufficient space in the mesiodistal dimensions was available for the placement of two adjacent dental implants (with minimum dimensions of 10×3.5 mm) with an interimplant distance of 3 mm and a tooth-toimplant distance of at least 1.5 mm; sufficient space in the mesiodistal, buccolingual, and interocclusal dimensions was available for the placement of two functional implant crowns with an anatomical design; and the implant site was free from infection. Exclusion criteria for this study were as follows: presence of medical and general contraindications for the surgical procedures; presence of an active and uncontrolled periodontal disease; bruxism; smoking; or a history of local radiotherapy to the head and neck region. All radiographic assessments were performed by a single researcher (NT), and esthetic index ratings were done by the same examiner throughout the evaluation period (KS). Clinical measurements and line measurements on photographs were done by a single examiner at a certain follow-up time but by different examiners throughout the period (NT and WGvN). Training and calibration was done to keep differences in measurements to a minimum.

Surgical and Prosthetic Procedures

To rehabilitate two adjacent missing teeth in the esthetic region, two treatment modalities were applied:

- The scalloped implant group (scalloped implant neck with extended approximal sides and internal abutment connection, test group), consisting of 20 patients treated with two adjacent implants with a scalloped implant platform (NobelPerfect Groovy, Nobel Biocare)
- The flat implant group (flat implant neck with internal abutment connection, control group), consisting of 20 patients treated with two adjacent implants with a flat implant platform (NobelPerfect Groovy).

Preoperatively, diagnostic casts were made with a diagnostic arrangement representing the future implant crown in the ideal prosthetic position. Next, this ideal crown position was translated into a surgical template by fabricating a transparent acrylic resin





Fig 1 Radiograph of two adjacent scalloped implants at $\rm T_5.$

Fig 2 Radiograph of two adjacent flat implants at T_5 .

template. One day before implant surgery, patients started taking antibiotics (amoxicillin 500 mg, 3 times daily for 7 days, or clindamycin 300 mg, 4 times daily for 7 days in case of amoxicillin allergy) and using a 0.2% chlorhexidine mouthwash (2 times daily for 7 days) for oral disinfection. Under local anesthesia, the implants were placed, according to the manufacturer's instructions, guided by the surgical template. The implants were placed with a maximum torque of 45 Ncm. Furthermore, when the bone apposition area of the implants remained uncovered after proper positioning in the coronal-apical direction, a local augmentation was performed. For this small simultaneous augmentation procedure, an autogenous bone graft, collected during drilling (from the grooves of the bur) or harvested intraorally, was combined with anorganic bovine bone (spongiosa granules, 0.25 to 1.0 mm, Bio-Oss, Geistlich Pharma) and overlaid with a Bio-Gides resorbable bilayer membrane (Geistlich Pharma). Three months after implant placement, the implants were uncovered and a healing abutment was placed. Single restorations were made. Restorations consisted of individual zirconia abutments covered with porcelain or individual zirconia abutments with separate zirconia cores with porcelain (either screwretained or cemented with glass-ionomer cement (Fuji Plus cement, GC). The patient was instructed in hygiene procedures associated with single crowns on dental implants (gentle tooth brushing and use of dental floss) and scheduled for routine maintenance recalls every 6 months.

Clinical Examinations

One month (T_0), 1 year (T_1), and 5 years (T_5) after the placement of the definitive implant restorations, the soft tissues around the adjacent implant-supported

restorations were clinically examined. The following parameters were assessed: papilla index according to Jemt,¹⁸ pocket probing depth, modified Plaque Index according to Mombelli et al,¹⁹ modified Bleeding Index according to Mombelli et al,¹⁹ and Gingiva Index according to Loë and Sillness.²⁰

Photographic Examinations

Standardized photographs of the implant restorations and surrounding soft tissues were taken (Meijndert et al²¹) and analyzed using computer software to perform linear measurements. The level of the marginal gingiva was assessed to the nearest 0.1 mm by measuring the vertical distance of the incisal edge of the crown to the tip of the papilla and to the border of the gingiva midbuccally. Examiners were blinded for the photographs.

Radiographic Examinations

Two weeks after implant placement (T_{post}) and 1 month (T_0) , 1 year (T_1) , and 5 years (T_5) after placement of the definitive restorations, digital periapical radiographs (Intra X-ray unit, Planmeca) were taken using a paralleling technique (Figs 1 and 2). The following linear measurements were assessed to the nearest 0.1 mm (for the scalloped implant group the apical corners of the implant collar were used as the reference line, and for the flat implant group the interface of the implant and the abutment was used as the reference line, from which all distances were measured):

- The first bone-to-implant level—the distance between the reference line and the first bone-toimplant level, measured at the implant side facing the adjacent implant and at the implant side facing the neighboring tooth
- The bone crest level—the distance between the reference line and the most coronal peak of the interimplant bone crest

The radiographic examination could not be blinded, as the study group could be deduced from these radiographs.

Implant Crown Aesthetic Index

Esthetic outcome by the professional was rated using the Implant Crown Aesthetic Index as described by Meijer et al²² by one and the same examiner at all evaluation periods (KS). The index was applied to both implant restorations separately and scored at T_1 and T_{r} .

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Table 1 Characteristics of the Study Groups at Baseline

	Scalloped implant group	Flat implant group
Number of participants	20	20
Age (y) (mean/range)	38.8/18-70	35.8/15-59
Gender (male/female)	9/11	11/9
Tooth gap position (I1-I1/I1-I2/I2-C/C-P1)	10/7/2/1	9/7/2/2
Augmentation prior to implant insertion (yes/no)	10/10	9/11
Local augmentation during implant insertion (yes/no)	13/7	12/8

I1 = central incisor; I2 = lateral incisor; C = canine; P1 = first premolar.



Fig 3 Consort flow diagram.

Patient Satisfaction

A subjective assessment of the results of the treatment was carried out at T_1 and T_5 using the questionnaire used by Meijndert et al.²³ Questions relating to overall score, color of the crown and mucosa, and shape of the crown and mucosa were used in the present study.

Statistical Analysis

All analyses were performed at implant level, except for patient satisfaction. Normality of data was tested with q-q plots and the Kolmogorov-Smirnov test. Where possible, differences between groups were analyzed using the independent *t* test. If the data violated the assumptions of a normal distribution, differences between the groups were analyzed using the Mann-Whitney test. In all statistical tests, a significance level of P = .05 was used.

Results

Patient characteristics per group at baseline are presented in Table 1. Despite the dropout of some patients at T_5 , both groups show a more or less equal distribution of balancing criteria. At T_1 , both groups were missing one patient for the evaluation. At T_5 , four patients in the scalloped implant group and one patient in the flat implant group could not be analyzed (Fig 3). The most cited reason for withdrawal was the

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		Bleedin	ıg index			Gingival index				
	Scalloped in	nplant group	Flat impla	Flat implant group		nplant group	Flat implant group			
Score	T_0 n = 20	n = 16	T_0 n = 20	T ₅ n = 19	T_0 n = 20	n = 16	T_0 n = 20	T_{5} n = 19		
0	9	7	12	19	30	20	34	36		
1	11	10	21	14	9	10	6	2		
2	19	13	7	5	1	2	0	0		
3	1	2	0	0	0	0	0	0		
Total	40	32	40	38	40	32	40	38		
		Bleeding Index				Gingival Index				
Difference	between groups	3	P = .016	*	$T_5 P = .001^*$	Т ₀ NS**	F	$P = .001^{***}$		

Table 2 Frequency Distribution of Bleeding Index and Gingival Index

*Peri-implant soft tissues around scalloped implants showed significantly more bleeding than around flat implants at T₁ and T₅. **No significant difference in inflammation of peri-implant soft tissues was found between the groups at T₀.

***Peri-implant soft tissues showed significantly more inflammation around scalloped implants than around flat implants at T₅.

 $T_0 = 1$ month after placement of the definitive restoration.

 $T_1 = 1$ year after placement of the definitive restoration.

 $T_5 = 5$ years after placement of the definitive restoration.

⁵ – 5 years arter placement of the definitive restora

Bleeding Index: 0 = no bleeding after probing

probing 0 = normal gingival/mucosa around tooth/implant

1 = isolated bleeding spots

1 = mild inflammation 2 = moderate inflammation

 $\begin{array}{ll} 2 = \text{confluent line of blood} & 2 \\ 3 = \text{heavy or profuse bleeding} & 3 \end{array}$

3 = severe inflammation

Table 3 Mean and SD of Pocket Probing Depth (mm) Measured Around Implants at the Proximal Sides Facing the Adjacent Implant, Midbuccally, and at the Proximal Sides Facing the Adjacent Tooth

	Scalloped implant group		Flat impla		
	T_0 n = 20	T_5 n = 16	T_0 n = 20	T_5 n = 19	
Location	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Significance
Proximal side facing adjacent implant	4.8 (1.5)	4.9 (2.0)	3.6 (1.3)	3.8 (1.2)	$T_0: P = .001^*$ $T_5: P = .012$
Midbuccally	4.1 (1.4)	4.8 (2.2)	3.1 (0.9)	3.0 (0.8)	T ₀ : <i>P</i> < .001** T ₅ : <i>P</i> < .001
Proximal side facing adjacent tooth	4.4 (1.8)	4.7 (2.4)	3.4 (1.4)	3.2 (1.1)	$T_0: P = .003^{***}$ $T_5: P = .003$

*Pocket probing depths at the proximal side of the implants facing the adjacent implant were significantly higher in the scalloped implant group than in the flat implant group at T₀ and T₅.

Pocket probing depths midbuccally of the implants were significantly higher in the scalloped implant group than in the flat implant group at T₀ and T₅. *Pocket probing depths at the proximal side of the implants facing the adjacent tooth were significantly higher in the scalloped implant group than in the flat implant group at T₀ and T₅.

in the flat implant group at $\rm T_{0}$ and $\rm T_{5}.$

 $T_0 = 1$ month after placement of the definitive restoration.

 $T_5 = 5$ years after placement of the definitive restoration.

distance to the Department of Oral and Maxillofacial Surgery after a change of address. The assumption was made that not attending the 5-year follow-up visit was independent of clinical outcome or satisfaction.

Clinical and Radiographic Assessments

Two implants in the same patient were lost in the scalloped implant group at T_5 , resulting in a 95% survival rate. The implants were lost 4 years after placement due to extensive peri-implant bone loss. No implants were lost in the flat implant group, resulting in a 100% survival rate. Plaque scores in both groups were low and showed no significant differences. The frequency distribution of the Bleeding Index and Gingival Index at the implants is given in Table 2. Bleeding scores were significantly higher in the scalloped implant group at T_0 (P = .016) and T_5 (P = .001) than in the flat implant group. Gingiva scores were significantly higher in the scalloped implant group at T_5 (P = .001) than in the flat implant group. Pocket probing depths at the implants are given in Table 3. The scalloped implant group showed significantly deeper probing depths than the flat implant group at T_0 and T_5 . Marginal gingiva levels

Table 4 Frequency Distribution of Papilla Index

	Scalloped platform group*				Flat platform group*				
	Т	0	T ₅		T ₀		T ₅		
Score	Adjacent implants	Implant- tooth	Adjacent implants	Implant- tooth	Adjacent implants	Implant- tooth	Adjacent implants	Implant- tooth	
0	5	0	6	1	5	0	3	1	
1	8	8	7	11	10	8	12	13	
2	6	25	3	15	4	23	3	19	
3	1	7	0	5	1	9	1	5	
4	0	0	0	0	0	0	0	0	
Total	20	40	16	32	20	40	19	38	

*No significant differences were found between groups at T₀ and T₅.

Papilla index scale: 0 = no papilla formation, 1 = less than half of papilla is present, 2 = at least half of papilla is present,

3 = papilla fills whole approximate space, 4 = abundance of papilla / hyperplastic papilla.

 $T_0 = 1$ month after the placement of the of the definitive crown.

 $T_5 = 5$ years after the placement of the of the definitive crown.

	Table 5	Mean and SD of	he Change in Marginal	Bone Level and Bone Crest Level
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	Scalloped implant group ($n = 16$)		Flat implant g	roup (n = 19)	
	T _{post} -T ₅	T ₁ -T ₅	T _{post} -T ₅	$T_1 - T_5$	
Location	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Difference
Interimplant bone crest level	-2.4 (1.0)	-0.8 (0.7)	-1.3 (1.0)	-0.1 (0.5)	T_{post} - T_1 : $P < .001^*$ T_1 - T_5 : $P < .001^*$
Marginal bone level facing the adjacent implant	-3.0 (1.1)	-0.6 (1.1)	-1.4 (0.9)	-0.4 (0.4)	$T_{post}^{-}-T_1: P < .001^{**}$ $T_1^{-}-T_5^{-}: NS^a$
Marginal bone level facing the adjacent tooth	-3.4 (1.0)	-1.0 (1.3)	-1.5 (0.7)	-0.6 (0.7)	T_{post} - T_1 : $P < .001^{***}$ T_1 - T_5 : NS ^a

*The interimplant bone crest loss was significantly higher in the scalloped implant group during the periods of $T_{post}-T_1$ and T_1-T_5 than in the flat implant group.

**The marginal bone loss at the side facing the adjacent implants was significantly higher in the scalloped implant group during the period of $T_{post}-T_1$ than in the flat implant group.

***The marginal bone loss at the side facing the adjacent tooth was significantly higher in the scalloped implant group during the period of T_{post}-T₁ than in the flat implant group.

^aNot significant.

 $T_{post} = directly after implant placement.$ $T_1 = 1$ year after placement of the definitive restoration.

 $T_5 = 5$ years after placement of the definitive restoration.

showed recession in both groups, with no significant differences. Both groups showed a compromised papilla presence and regeneration with no significant differences between groups (Table 4).

Table 5 shows the results of the marginal bone changes from $\rm T_{post}$ to $\rm T_{5}$ and $\rm T_{1}$ to $\rm T_{5}.$ Between $\rm T_{post}$ and $\rm T_{5},$ the marginal bone loss was significantly higher around the scalloped implants. The approximal side facing the adjacent implant showed a marginal bone loss of 3.4 mm in the scalloped implant group (compared to 1.5 mm in the flat implant group). The interimplant bone crest also showed a significantly

higher marginal bone loss of 2.4 mm (compared to 1.3 mm in the flat implant group). The marginal bone loss around the scalloped implants between T_1 and T_5 was not significantly different from the bone loss around the flat implants.

The Implant Crown Aesthetic index rated the majority of patients as having poor esthetics, with no significant differences between groups. The results of the patient questionnaire are shown in Table 6. Patient satisfaction was very high. Mean overall scores were 8.4 for the scalloped implant group and 9.1 for the flat implant group.

Table 6	Results	of the	Patient	Questionnaire
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	T ₁ '	k	T	-	
Satisfaction	Scalloped (n = 19) Mean (SD)	Flat (n = 19) Mean (SD)	Scalloped (n = 16) Mean (SD)	Flat (n = 19) Mean (SD)	Difference at $T_5(P)$
Overall score	8.3 (1.2)	8.6 (0.8)	8.4 (1.7)	9.1 (0.8)	NS**
Color of mucosa	2.8 (1.2)	3.0 (1.2)	2.8 (1.2)	3.5 (0.6)	NS**
Shape of mucosa	2.4 (1.2)	2.8 (1.2)	2.5 (1.2)	3.4 (0.6)	.014***
Color of crown	3.5 (0.8)	3.7 (0.6)	3.6 (0.8)	3.7 (0.6)	NS**
Shape of crown	3.2 (0.9)	3.3 (1.2)	3.5 (0.5)	3.7 (0.6)	NS**

Overall satisfaction (range 0–10): 0 = very dissatisfied, 10 = very satisfied.

Mucosa and crown satisfaction (range 0–4): 0 = very dissatisfied, 4 = very satisfied.

 $T_1 = 1$ year after placement of the definitive restoration.

 $T_5 = 5$ years after placement of the definitive restoration.

*No significant differences were found between groups at T₁.

**No significant differences were found between groups at T₅.

***The shape of the mucosa was rated significantly lower in the scalloped group than in the flat group at T5.

Discussion

Bone loss, inflammation and bleeding of the periimplant soft tissues, and pocket probing depths were greater around scalloped implants than around flat implants. Marginal recession of the peri-implant soft tissues occurred in both groups with no significant differences. The interimplant papilla showed compromised regeneration and was unable to maintain its shape in both groups. Although treatment results were often judged as poor by professional observers, patient satisfaction regarding the esthetic outcome was very high.

The implant survival rate after 5 years of function was 95% for the scalloped implant group and 100% for the flat implant group. Two implants were lost in the scalloped group after ongoing bone loss as a result of peri-implantitis (after 4 years of functioning). The implant survival of the flat implant group is comparable to another study reporting on implants with the same titanium oxide surface (TiUnite, Nobel Biocare)²⁴ as the one used in this study. The implant survival rate of the scalloped group is comparable to the one reported by Noelken et al.²⁵ No articles had reported on the survival rate after 5 years of two adjacent implants. Therefore, no true comparison could be made with the present study.

The mean marginal bone loss around the implants during the period from T_{post} to T_5 was significantly higher in the scalloped implant group than in the flat implant group. The marginal bone loss was 3.0 mm at the approximal side facing the adjacent implant and 3.4 mm at the approximal side facing the adjacent tooth for the scalloped implant group. The marginal bone loss in the flat implant group was 1.4 mm at the approximal side facing the adjacent implant and 1.5 mm at the approximal side facing the adjacent tooth for the flat implant group. That approximal sides

of the scalloped implants were (partially) augmented with bone could be a factor. This augmented bone could have been subject to resorption. Mean marginal bone loss in the flat implant group is comparable with the results of articles reporting on the same implant system (TiUnite, Nobel Biocare) used in single-tooth replacement.^{24,26} Comparing results with other studies is difficult, because no comparable 5-year studies on two adjacent implants are available. In the period from T₁ to T₅, both groups showed less marginal bone loss compared with the period from T_{post} to T₁. The cumulative mean marginal bone loss was 0.8 mm around scalloped implants and 0.5 mm around flat implants during the period from T_1 to T_5 , resulting in no significant differences. Therefore, it seems that in the short term the scalloped three-dimensional platform of the scalloped implant design is unable to maintain marginal bone levels,¹⁰ but in the long term no significant differences are found between groups regarding the stability of the marginal bone levels. The interimplant bone crest did show a significant difference in mean interimplant bone crest loss during both periods from $\rm T_{post}$ to $\rm T_{5}$ and $\rm T_{1}$ to $\rm T_{5}.$ During the period from $\rm T_{post}$ to $\rm T_{5},$ mean interimplant bone crest loss was 2.4 mm between the scalloped implants and 1.3 mm between the flat implants. Between T_1 and T_5 , the interimplant bone crest loss was 0.8 mm between the scalloped implants and 0.1 mm between the flat implants. The significantly higher interimplant bone crest loss is presumably caused by two factors. First, the marginal bone loss around the separate implants is higher around scalloped implants than around flat implants. With adjacent implants these resorbed peri-implant regions probably meet, resulting in resorption of the interimplant bone crest.²⁷ Second, the mean horizontal distance of 3.2 mm between adjacent scalloped implants was significantly smaller than the mean horizontal distance of 3.8 mm between the adjacent

flat implants.⁹ Furthermore, there were more patients in the scalloped implant group with a horizontal distance of less than 3 mm than in the flat implant group. This could be due in part to the design of the narrow scalloped implants placed at the position of the lateral incisor. The scalloped implant placed at this site has a neck with a diameter of 4.31 mm instead of the 3.54 mm of the flat implant. A horizontal interimplant distance smaller than 3 mm will result in more horizontal and vertical interimplant bone crest loss.²⁷ This is predominantly caused by the overlap of the bone resorption areas between adjacent implants.²⁸ Criteria for implant success as stated by Albrektsson et al²⁹ propose an average bone loss of a maximum of 1.5 mm in the first year after implant placement and a further annual bone loss of less than 0.2 mm. The flat implant group meets these criteria for success; however, the scalloped implant group does not.

Plaque scores were low in both groups. The Bleeding Index and Gingival Index around the implants gave significantly higher scores in the scalloped group than in the flat group. Mean pocket probing depths were deeper around scalloped implants than around flat implants. At T₅, the mean pocket probing depths next to the scalloped implants ranged from 4.7 mm at the proximal side facing the adjacent tooth to 4.9 mm at the proximal side facing the adjacent implant. This was significantly higher than in the flat implant group. The probing depths in the flat group are comparable with those reported in studies on singletooth replacement.^{30,31} The deeper pocket probing depths around the implants in the scalloped implant group most likely reflect the significantly greater marginal bone loss around the scalloped implants.

During the 5 years following implant placement, changes in the marginal gingiva level around both implant designs were small. This indicates that the marginal gingiva level remains fairly stable after implant therapy. Multiple studies reporting on single-tooth replacement showed comparable results.^{32,33} Papilla index scores in both groups pointed out the partial absence of papillae in both groups, with no significant differences between the groups. There seems not to be a one-to-one relationship between bone height and presence of papillae. More factors are likely involved.⁸ The interimplant papilla showed less favorable scores in both groups when compared to the papillae between the implant and the tooth. The interimplant bone crest is a dominant factor in maintaining the interimplant papilla. The reduced height of this bone crest causes the interimplant papilla to collapse, as the soft tissues tend to follow the contour of the hard tissues. Moreover, the soft tissue height of the interimplant papilla is lower than the papillae between the implant and tooth. The maximum soft tissue height of the interimplant papilla is 3 to 4 mm compared to the 5 mm of the papillae between an implant and a tooth.²⁷ These factors contribute to the compromised presence of the papilla between two adjacent implants in both groups. If papillae are not to be expected because of a compromised bone height between two implants, black triangles due to absence of soft tissue are prevented by manipulating the contact area between the crowns. The contact area is extended cervically. Both groups experienced loss of the bone crest, so in both groups a substantial part of the papilla was missing and contact areas of adjacent crowns were adjusted in both groups.

A self-administered nonvalidated questionnaire was used and applied in this study for comparison with previous and ongoing research. Patient satisfaction in both groups was very high. At T₅, mean overall scores were 8.4 (range: 0 to 10) for the scalloped implant group and 9.1 for the flat implant group. There is hardly any difference at T_5 compared to T_1 , meaning that patient satisfaction was stable after the first year. In contrast, the professionals rated the majority of patients as having poor esthetics. This difference in rating by patients and professionals has been seen in earlier studies. The study by Meijndert et al,23 which was also on implant-based restorations in the esthetic region and used the same index and questionnaires, found that patients were much more satisfied than was expected after rating esthetics by professionals. A reason for this paradox could be the fact that preoperative bone conditions for adjacent implants could be poor among patients with a history of trauma. As a result, more than half the patients in both groups had undergone augmentation procedures to compensate for the large defect. Therefore, the final result was probably very satisfying for these patients. Moreover, patients were informed about the risks and consequences of implant placement and the limitations of two adjacent implants regarding soft tissue regeneration. Factors considered important by professionals therefore may not be of paramount importance to patients.23,34

Conclusions

From the present study, it can be concluded that regardless of the implant design used, it was difficult to establish a predictable and harmonious result with adjacent implants in the esthetic region. After the first year of more bone loss and compromised interimplant papilla regeneration around scalloped compared to flat implants, the following 4 years presented stable results with both systems. Scalloped implants seem to have no beneficial use compared to conventional flat implants in the esthetic region.

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