

# Implant treatment of two failing or missing central incisors in the aesthetic region: a treatment protocol and 1-year prospective study

W. G. van Nimwegen<sup>1</sup>,  
G. M. Raghoobar<sup>1</sup>, A. Vissink<sup>1</sup>,  
H. J. A. Meijer<sup>1,2</sup>

<sup>1</sup>Department of Oral and Maxillofacial Surgery, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands; <sup>2</sup>Department of Implant Dentistry, Dental School, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands

W. G. van Nimwegen, G. M. Raghoobar, A. Vissink, H. J. A. Meijer: Implant treatment of two failing or missing central incisors in the aesthetic region: a treatment protocol and 1-year prospective study. *Int. J. Oral Maxillofac. Surg.* 2019; 48: 1115–1121. © 2019 International Association of Oral and Maxillofacial Surgeons. Published by Elsevier Ltd. All rights reserved.

**Abstract.** Implant treatment for two central incisors in the maxillary aesthetic region is complex due to concerns regarding inter-implant hard and soft tissue stability. A treatment protocol was therefore developed and implemented in a 1-year prospective case series study involving 16 patients with two failing or missing central incisors in the maxillary aesthetic region. The protocol consists of five options depending on whether teeth are still present (options 13) or not (options 4 and 5) and on the amount of bone available at the start of treatment: (1) extraction followed by immediate implant placement and provisionalization, (2) extraction followed by immediate implant placement and delayed provisionalization, (3) extraction followed by ridge preservation, delayed implant placement and immediate provisionalization, (4) delayed implant placement and guided bone regeneration with delayed provisionalization, (5) guided bone regeneration (extensive bone augmentation of the alveolar ridge), delayed implant placement, and delayed provisionalization. The patients were assessed regarding peri-implant hard and soft tissue parameters, aesthetic index score, and patient satisfaction. All treatment options showed good clinical and radiographic results and high patient satisfaction.

Key words: adjacent implants; aesthetic zone; dental implants; treatment proposal.

Accepted for publication 11 January 2019  
Available online 1 February 2019

Failure of two adjacent central incisors in the maxillary aesthetic region creates a difficult challenge for dental professionals<sup>1,2</sup>. The extraction of these teeth is

often preceded by a history of trauma and endodontic treatment or retreatment. When these teeth must be removed, periapical inflammation and root resorption

often result. Prior to the introduction of dental implants, such cases were usually treated with conventional fixed dental prostheses or removable partial dentures.

Nowadays, implant treatment enables the replacement of these failing teeth with implant-supported solutions.

Despite high reported implant survival rates<sup>1,3</sup>, the placement of two adjacent implants in the aesthetic region is considered a complex treatment due to the risk of loss of peri-implant hard and soft tissue and aesthetic concerns, especially in the inter-implant region<sup>4</sup>. The implant protocol that is used can influence the final outcome, especially peri-implant soft tissue aesthetics<sup>5</sup>.

In the case of a single failing tooth in the maxillary aesthetic region, promising results have been reported for immediate implant placement and immediate provisionalization<sup>6,7</sup>. In the case of buccal bony defects, immediate implant placement with delayed provisionalization and delayed implant placement have shown their merit<sup>8</sup>. However, it appears that no study has yet been published on the use of such single-tooth implant protocols for two adjacent implants, so it is uncertain whether these protocols can be applied to adjacent implant treatment.

In the study presented here, an implant treatment protocol was developed consisting of five treatment options for the re-

placement of two adjacent failing or missing central incisors in the maxillary aesthetic region. To assess the outcomes of these treatment options, they were tested in a 1-year prospective study.

**Materials and methods**

**Treatment protocol for two central incisors**

Based on an established treatment protocol for single tooth replacement in the maxillary aesthetic region<sup>7,8</sup>, five treatment options for two failing or missing central incisors are considered (Fig. 1), depending on whether teeth are still present (options 13) or not (options 4 and 5), as outlined below.

Options 13 involve the extraction of failing teeth and consecutive treatment: (1) option 1 comprises immediate implant placement and provisionalization; (2) option 2 comprises immediate implant placement with delayed provisionalization; (3) option 3 comprises ridge preservation, followed by delayed implant placement and immediate provisionalization. Options 4 and 5 involve a healed site and consecutive

treatment: (4) option 4 comprises implant placement and guided bone regeneration with delayed provisionalization; (5) option 5 comprises guided bone regeneration (extensive bone augmentation on the buccal and palatal aspect of the alveolar ridge), delayed implant placement, and delayed provisionalization.

*Preoperative screening*

The patients medical history and periodontal condition are assessed. The keratinized mucosa is measured to ensure a keratinized mucosa thickness of 2 mm<sup>9</sup>. Cone beam computed tomography (CBCT) is done to determine whether there is sufficient palatal bone volume for primary implant stability. Based on the bone condition seen on CBCT and the presence or absence of failing teeth, a preliminary treatment choice is made (Fig. 1).

*Options 13: failing teeth, post-extraction assessment, consecutive treatment*

In the case of failing teeth, mid-buccal mucosa levels of the failing teeth are

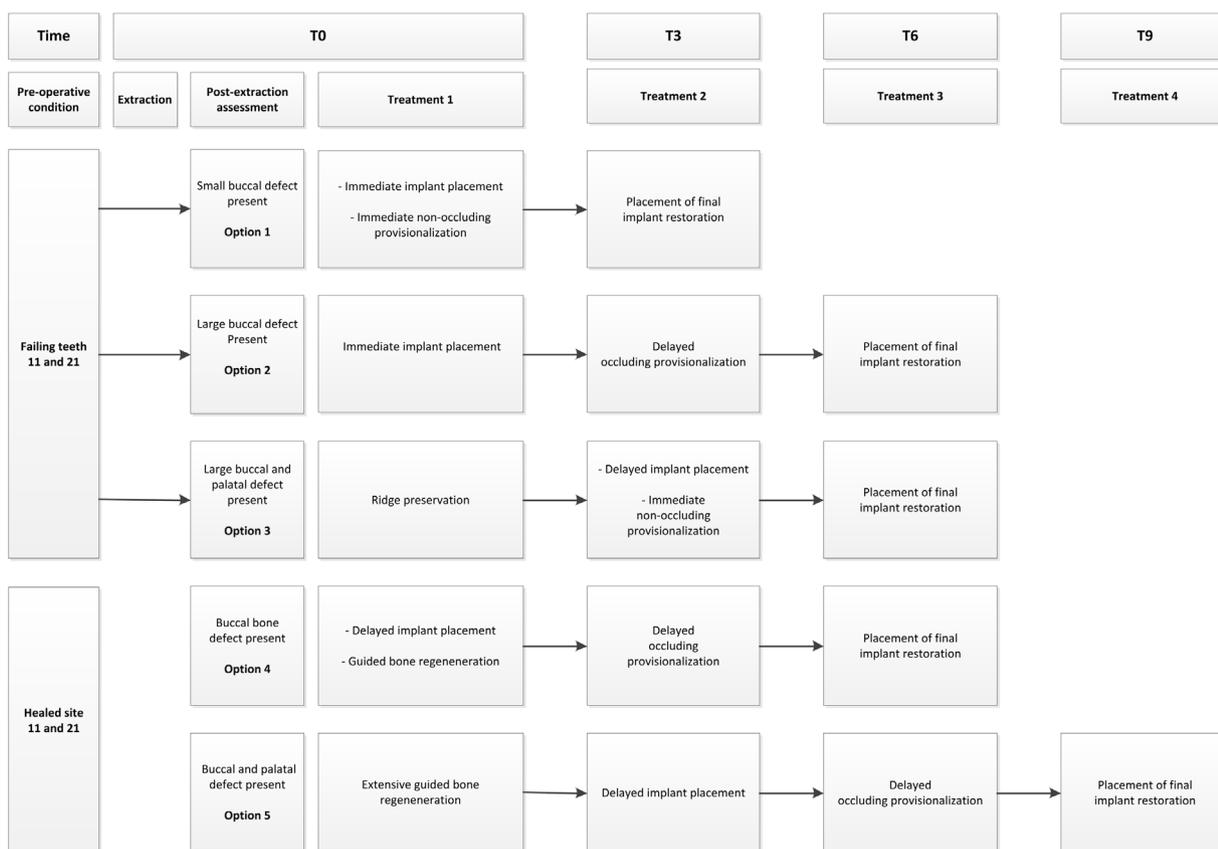


Fig. 1. Flow chart showing patient allocation to the five treatment options for implant treatment of two failing or missing central incisors in the maxillary aesthetic region and the stages of treatment.

assessed preoperatively for asymmetry with the neighbouring teeth. Symmetrical mucosa levels allow immediate implant placement and provisionalization (option 1). Asymmetry of 2 mm excludes the possibility of immediate provisionalization (option 2).

Next, extraction is performed without raising a flap. The alveolar bone geometry is assessed by bone sounding technique with a periodontal probe (Williams Color-Coded Probe; Hu-Friedy, Chicago, IL, USA) at the buccal, mesial, and distal aspects of the failing teeth and the proximal sides of the adjacent teeth facing the alveoli. In the case of a post-extraction defect of the buccal bone wall, this defect is measured to determine the treatment option. A bony defect and a distance measured in a vertical direction from the bony defect of the buccal bone wall to the mucosa at the cementenamel junction of the adjacent tooth of 5 mm (for example, 3 mm bony defect and 2 mm mucosa) allows immediate implant placement and provisionalization (option 1). A distance of >5 mm excludes the possibility of immediate provisionalization (option 2). When no primary implant stability can be reached, option 3 is applied.

For option 1 (immediate implant placement and provisionalization), symmetrical mucosa levels, sufficient palatal bone

(CBCT) for primary implant stability, and a buccal defect of 5 mm allows immediate implant placement and provisionalization (Fig. 2a). After removal of the teeth, two implant sites are prepared on the palatal side of the alveoli using a surgical template representing the ideal position of the prospective implant restorations. The last implant drill used, depending on the diameter of the implants required, is placed in the prepared alveoli. The space remaining between the implant drill and the peri-implant bone is locally augmented. As grafting material, a 1:1 mixture of autogenous bone (harvested from the tuberosity region) and inorganic bone (Bio-Oss; Geistlich Pharma AG, Wolhusen, Switzerland) is used. Two implants with an expanding taper (NobelActive; Nobel Biocare AG, Kloten, Switzerland) are then inserted 3 mm apical to the most apical aspect of the prospective implant restoration. Primary stability is achieved with insertion torque of 45 N·cm. Within 24 hours after implantation, two non-occluding screw-retained provisional restorations are placed. Three months later, two final screw-retained implant restorations are fabricated and fixated on the implants (Fig. 2b).

For option 2 (immediate implant placement, delayed provisionalization), sufficient palatal bone (CBCT) for primary

stability of the implants, an asymmetrical mucosa level of >2 mm and/or a buccal defect of >5 mm allows immediate implant placement and delayed provisionalization. The implant sites are prepared in the same manner as for option 1 and the space remaining between the last implant drill and the peri-implant bone and buccal bony defects is augmented with a 1:1 mixture of autogenous bone and inorganic bone (Bio-Oss). Next, two implants with an expanding taper (NobelActive) are inserted with the aid of a surgical template with insertion torque of 45 N·cm. Both implant sites are closed with a mucosa graft harvested from the tuberosity region. After 2 weeks of soft tissue healing, the sutures are removed. Following a 3-month submerged healing phase, two occluding screw-retained provisional restorations are placed. Six months after implant placement, two final screw-retained implant restorations are fabricated and fixated on the implants.

For option 3 (ridge preservation, delayed implant placement and immediate provisionalization), a lack of palatal bone (CBCT), compromised primary stability of the implants, and a buccal defect of >5 mm preclude options 1 and 2. The alveoli are augmented with a 1:1 mixture of autogenous bone from the tuberosity region and inorganic bovine bone (Bio-Oss). Next, both alveoli are closed with a mucosa graft harvested from the tuberosity region. After 2 weeks of soft tissue healing, the sutures are removed. Following a 3-month healing phase, two implants with an expanding taper (NobelActive) are inserted with the aid of a surgical template representing the ideal position of the prospective implant restorations. Primary stability is achieved with insertion torque of 45 N·cm. Within 24 hours after implant placement, two non-occluding screw-retained provisional restorations are placed. Three months after implant placement, two final screw-retained implant restorations are fabricated and fixated on the implants.

#### *Options 4 and 5: healed site and consecutive treatment*

If a healed site is present, buccal and palatal full thickness flaps are raised to assess the bone geometry and the subsequent treatment is chosen.

For option 4 (implant placement and guided bone regeneration, delayed provisionalization), sufficient palatal bone (CBCT) for primary implant stability allows delayed implant placement. First, two implants with an expanding taper



Fig. 2. (a) Preoperative photograph of two failing maxillary central incisors. (b) Photograph of the final implant restorations, taken within 1 month after their placement (T<sub>1</sub>).

(NobelActive) are inserted with the aid of a surgical template representing the ideal position of the prospective implant restorations. Primary stability is achieved with insertion torque of 45 N·cm. If parts of the implant remain uncovered or the buccal bone wall thickness is <2 mm<sup>10</sup>, a local augmentation procedure is performed with a mixture of autogenous bone chips collected during implant bed preparation and inorganic bovine bone (Bio-Oss), which is covered with a resorbable collagen membrane (Bio-Gide; Geistlich Pharma AG). The wounds are closed with non-resorbable sutures (primary wound closure). After 2 weeks of soft tissue healing, the sutures are removed. Following a 3-month submerged healing phase, two occluding screw-retained provisional restorations are placed. Six months after implant placement, two final screw-retained implant restorations are fabricated and fixated on the implants.

For option 5 (guided bone regeneration (extensive bone augmentation of the alveolar ridge), delayed implant placement, delayed provisionalization), insufficient bone (CBCT) for primary stability of the implants necessitates an extensive guided bone regeneration procedure. The bony defects are reconstructed with autogenous bone blocks harvested from the retromolar region. The wounds are closed primarily with non-resorbable sutures. After 2 weeks of soft tissue healing, the sutures are removed. Following a 3-month healing phase, a full thickness flap is raised and two implants with an expanding taper (NobelActive) are placed with the aid of a surgical template representing the ideal position of the prospective implant restorations. Next, the wounds are closed primarily with non-resorbable sutures. After 2 weeks of soft tissue healing, the sutures are removed. Following a 3-month submerged healing phase, two occluding screw-retained provisional restorations are placed. Six months after implant placement, two final screw-retained implant restorations are fabricated and fixated on the implants.

## Case series

### Study design

Consecutive patients referred to the Department of Oral and Maxillofacial Surgery of the University Medical Centre Groningen (University of Groningen, Groningen, the Netherlands) between April 2011 and July 2015 with two failing or missing maxillary central incisors were enrolled in the study. All eligible patients

were informed about the features of the study and gave their informed consent before enrolment.

### Eligibility criteria

Fulfilment of the inclusion criteria was verified by clinicians at the screening session, including the following: 18 years of age; failing or missing teeth are central upper incisors; natural teeth are located distally (regions 12 and 22) and opposing the failing or missing teeth; adequate oral hygiene; sufficient mesialdistal, buccalpalatal, and inter-occlusal space for the placement of implants and final restorations; sufficient inter-occlusal space to design non-occluding provisional restorations.

The following exclusion criteria were applied: medical or general contraindication to the surgical procedure (American Society of Anesthesiologists (ASA) status III<sup>11</sup>); presence of active periodontal disease (pocket probing depth 4 mm and bleeding on probing); excessive smoking (10 cigarettes per day); history of head and neck radiotherapy; pregnancy.

Depending on the presence or absence of teeth and the available bone and soft tissue, patients were allocated to one of the five treatment options (Fig. 1). The surgical and prosthetic procedures have been described in detail by Slagter et al.<sup>7</sup> All surgical procedures were performed by one oral and maxillofacial surgeon (G.M.R.). All prosthetic procedures were done by one prosthodontist (H.J.A.M.).

### Outcome measures

Study parameters were collected at three time points: 2 weeks after implant surgery (T<sub>P</sub>), within 1 month after placement of the final implant restoration (T<sub>1</sub>), and 1 year after placement of the final implant restoration (T<sub>12</sub>). All clinical parameters at T<sub>1</sub> and T<sub>12</sub> were assessed by one examiner (W.G.V.N.). The following parameters were assessed: implant survival<sup>12</sup> (T<sub>12</sub>); biological and technical complications (T<sub>12</sub>); change in marginal bone level (T<sub>P</sub>T<sub>12</sub>); change in inter-implant bone crest level (T<sub>P</sub>T<sub>12</sub>); implant probing depth (T<sub>1</sub> and T<sub>12</sub>); papilla index<sup>13</sup> (T<sub>1</sub> and T<sub>12</sub>); plaque index<sup>14</sup> (T<sub>1</sub> and T<sub>12</sub>); gingiva index<sup>15</sup> (T<sub>1</sub> and T<sub>12</sub>); bleeding index<sup>14</sup> (T<sub>1</sub> and T<sub>12</sub>); pink aesthetic score and white aesthetic score (PESWES)<sup>16</sup> (T<sub>12</sub>); patient satisfaction<sup>17</sup> (T<sub>12</sub>).

Implant survival was defined as the percentage of functional implants at follow-up (T<sub>12</sub>).

Digital peri-apical radiographs (Planmeca Intra X-ray unit; Planmeca, Helsinki, Finland) were taken at T<sub>P</sub>, T<sub>1</sub>, and T<sub>12</sub> using a paralleling technique. The known length and width of the implants were used to calibrate the radiographs. The implant collar was used as a reference line to determine the following measurements to the nearest 0.1 mm (Tymstra et al.<sup>3</sup>): marginal bone level facing the adjacent teeth (MBL-t); marginal bone level facing the adjacent implant (MBL-ii); inter-implant bone crest level (BC-ii). All radiographic measurements were performed twice by one examiner (W.G.V.N.), after which the average of the two measurements was used.

The aesthetic outcome was assessed on standardized digital photographs<sup>17</sup> (Canon EOS 650 with ring flash; Canon Inc., Ota, Tokyo, Japan) taken at T<sub>12</sub>. Peri-implant soft tissue and implant crown aesthetics were determined with the PESWES. All measurements were performed in a blinded manner by two examiners (H.J.A.M., W.G.V.N.), in random order.

Patients received a validated questionnaire<sup>17</sup> prior to the assessment at T<sub>12</sub> and were asked to complete questions relating to their overall satisfaction score (numerical rating scale of 0-10, with 10 being highest possible score) and satisfaction regarding the colour of the crown and mucosa and the shape of the crown and mucosa (numerical rating scale of 0-4, with 4 being the highest possible score).

### Statistical analysis

Due to the small number of patients, descriptive statistics were used.

## Results

### Patient characteristics

During the study recruitment period, 16 eligible consecutive patients were treated according to the implant treatment protocol presented above (option 1, *n* = 4; option 2, *n* = 3; option 3, *n* = 3; option 4, *n* = 3; option 5, *n* = 3). Nine of the patients were male (mean age 29 years, range 18-63 years) and seven were female (mean age 36 years, range 18-55 years). All patients were treated according to the treatment protocol after preoperative assessment. All patients underwent clinical assessments at T<sub>1</sub> and T<sub>12</sub>.

### Implant survival

No implants were lost during the 1-year follow-up (implant survival rate 100%).

Morbidity at the donor sites was low and wound healing of the grafting sites and implant sites was uneventful. No sensory disturbances occurred.

**Biological and technical complications**

No biological or technical complications were seen during follow-up.

**Radiographic assessment**

The changes in BC-ii, MBL-ii, and MBL-t between T<sub>P</sub> and T<sub>1</sub> and between T<sub>1</sub> and T<sub>12</sub> are shown in Table 1. The total change in BC-ii between T<sub>P</sub> and T<sub>12</sub> ranged from 0.21 mm (standard deviation (SD) 0.56) (option 4) to 1.94 mm (SD 2.48) (option 2). The total change in MBL-ii between T<sub>P</sub> and T<sub>12</sub> ranged from 0.21 mm (SD 0.05) (option 4) to 1.16 mm (SD 1.60) (option 2). The total change in MBL-t between T<sub>P</sub> and T<sub>12</sub> ranged from 0.20 mm (SD 0.37) (option 1) to 0.64 mm (SD 0.48) (option 5).

**Clinical assessment**

The health of the keratinized gingiva remained stable. Papilla index scores for the inter-implant papillae and the papillae facing the adjacent teeth at T<sub>1</sub> and T<sub>12</sub> are listed in Table 2. All treatment options showed incomplete fill of the peri-implant papillae at T<sub>1</sub> and T<sub>12</sub>. The implant probing depths of the two proximal sides (facing the implant and facing the adjacent teeth) and mid-buccally at T<sub>1</sub> and T<sub>12</sub> are listed in Table 3. All implant probing depths were low and did not exceed 3.2 mm. The gingiva index scores were low at T<sub>1</sub> and T<sub>12</sub>, with no mucosal inflammation (score 0) or mild inflammation (score 1) seen for all options. In addition, bleeding index scores were low at T<sub>1</sub> and T<sub>12</sub> for all options, with no bleeding (score 0) or isolated bleeding spots found after probing (score 1). Plaque scores were very low (score 0 = no plaque) during follow-up, with the exception of one patient (option 4) at T<sub>12</sub> (score 2: plaque visible to the eye).

**Aesthetic assessment**

The PESWES scores at T<sub>12</sub> are listed in Table 4. The mean PES score ranged from 5.33 (SD 2.08) (option 3) to 7.75 (SD 0.96) (option 1).

**Patient satisfaction**

Patient satisfaction scores at T<sub>12</sub> are listed in Table 5. Overall satisfaction scores

Table 1. Changes in marginal bone level and bone crest level; mean (SD) values in millimetres.

Location	Option 1 n = 4		Option 2 n = 3		Option 3 n = 3		Option 4 n = 3		Option 5 n = 3	
	T <sub>P</sub> T <sub>1</sub>	T <sub>1</sub> T <sub>12</sub>	T <sub>P</sub> T <sub>1</sub>	T <sub>1</sub> T <sub>12</sub>	T <sub>P</sub> T <sub>1</sub>	T <sub>1</sub> T <sub>12</sub>	T <sub>P</sub> T <sub>1</sub>	T <sub>1</sub> T <sub>12</sub>	T <sub>P</sub> T <sub>1</sub>	T <sub>1</sub> T <sub>12</sub>
BC-ii	0.92 (0.72)	0.53 (0.90)	1.41 (1.40)	0.53 (1.22)	1.20 (1.61)	0.62 (0.40)	0.09 (0.52)	0.12 (0.13)	0.20 (0.60)	0.37 (0.30)
MBL-ii	0.10 (0.29)	0.19 (0.41)	0.86 (0.61)	0.30 (1.00)	0.57 (0.67)	0.26 (0.43)	0.38 (0.40)	+0.17 (0.39)	0.53 (0.32)	+0.06 (0.24)
MBL-t	0.13 (0.16)	0.07 (0.31)	0.24 (0.52)	0.03 (0.40)	0.61 (0.76)	+0.02 (0.14)	0.38 (0.36)	+0.20 (0.44)	0.58 (0.28)	0.06 (0.20)

BC-ii = change in inter-implant bone crest level; MBL-ii = change in inter-implant marginal bone level; MBL-t = change in implant marginal bone level facing the adjacent teeth; T<sub>P</sub> = directly after implant placement; T<sub>1</sub> = 1 month after placement of the final restoration; T<sub>12</sub> = 1 year after placement of the final restoration; SD, standard deviation.

Table 2. Papilla index; mean (SD) scores<sup>a</sup>.

Location	Option 1 n = 4		Option 2 n = 3		Option 3 n = 3		Option 4 n = 3		Option 5 n = 3	
	T <sub>1</sub>	T <sub>12</sub>								
Between implants	1.25 (0.96)	0.75 (0.50)	1.33 (0.58)	1.00 (1.00)	0.33 (0.58)	0.33 (0.58)	0.33 (0.58)	0.00 (0.00)	0.33 (0.58)	0.33 (0.58)
Towards adjacent teeth	1.87 (0.75)	1.62 (0.75)	2.00 (0.50)	2.17 (0.76)	1.50 (0.50)	1.67 (0.29)	1.50 (0.00)	1.33 (0.29)	1.33 (0.76)	1.00 (0.87)

T<sub>1</sub> = 1 month after placement of the final restoration; T<sub>12</sub> = 1 year after placement of the final restoration; SD, standard deviation.

<sup>a</sup>Papilla index: score 0 = no papilla formation; score 1 = less than half of the papilla is present; score 2 = at least half of the papilla is present; score 3 = papilla fills the whole approximate space; score 4 = abundance of papilla/hyperplastic papilla.

Table 3. Implant probing depth measured around implants at the proximal sides facing the adjacent implant, mid-buccally, and at the proximal sides facing the adjacent tooth; mean (SD) values in millimetres.

Location	Option 1 n = 4		Option 2 n = 3		Option 3 n = 3		Option 4 n = 3		Option 5 n = 3	
	T <sub>1</sub>	T <sub>12</sub>								
Proximal sides facing the adjacent implant	3.00 (0.87)	2.87 (0.85)	2.33 (0.58)	2.67 (1.15)	2.83 (0.76)	3.00 (0.00)	2.50 (0.50)	3.17 (1.15)	2.67 (0.29)	3.00 (0.50)
Mid-buccally	2.50 (0.58)	2.25 (0.50)	2.00 (0.00)	2.33 (0.58)	2.67 (0.76)	2.67 (0.58)	2.33 (0.58)	2.83 (1.04)	2.00 (0.00)	2.67 (0.58)
Proximal sides facing the adjacent tooth	3.12 (0.63)	3.00 (0.82)	2.33 (0.58)	2.33 (0.58)	2.17 (0.29)	2.67 (0.58)	2.50 (0.00)	2.50 (0.50)	2.17 (0.58)	2.50 (0.50)

T<sub>1</sub> = 1 month after placement of the final restoration; T<sub>12</sub> = 1 year after placement of the final restoration; SD, standard deviation.

Table 4. Pink aesthetic score (PES) and white aesthetic score (WES) at 1 year after placement of the final restoration (T<sub>12</sub>); mean (SD) values.

	Option 1 n = 4	Option 2 n = 3	Option 3 n = 3	Option 4 n = 3	Option 5 n = 3
PES	7.75 (0.96)	7.00 (1.00)	5.33 (2.08)	5.67 (1.15)	5.67 (0.58)
WES	7.50 (3.00)	5.33 (1.53)	6.33 (1.15)	7.67 (0.58)	6.67 (1.53)
PESWES	15.25 (3.59)	12.33 (2.52)	11.67 (1.53)	13.33 (0.58)	12.33 (2.08)

SD, standard deviation.

Table 5. Results of the patient questionnaire at 1 year after placement of the final restoration (T<sub>12</sub>); mean (SD) scores<sup>a</sup>.

	Option 1 n = 4	Option 2 n = 3	Option 3 n = 3	Option 4 n = 3	Option 5 n = 3
Overall score	9.00 (1.15)	8.67 (0.58)	9.33 (1.15)	10.00 (0.00)	9.33 (0.58)
Colour of mucosa	3.75 (0.50)	3.33 (0.58)	3.67 (0.58)	3.67 (0.58)	3.67 (0.58)
Shape of mucosa	3.5 (0.58)	3.00 (1.00)	3.67 (0.58)	3.00 (1.00)	3.33 (1.15)
Colour of crown	3.75 (0.50)	3.67 (0.58)	4.00 (0.00)	4.00 (0.00)	4.00 (0.00)
Shape of crown	4.00 (0.00)	3.67 (0.58)	3.67 (0.58)	4.00 (0.00)	4.00 (0.00)

SD, standard deviation.

<sup>a</sup> Overall satisfaction score (range 010): 0 = very dissatisfied, 10 = very satisfied. Satisfaction score, mucosa and crown (range 04): 0 = very dissatisfied, 4 = very satisfied.

were very high for all options (range 8.6710.00).

**Discussion**

In the study presented here, a protocol with five implant treatment options for specific conditions accompanying two failing or missing central incisors in the maxillary aesthetic zone is proposed. This protocol was tested in a prospective study involving patients with two failing or missing maxillary central incisors and differences in the degree of bone resorption. The study resulted in a 1-year implant survival rate of 100%, good clinical and radiographic results, and high patient satisfaction for all treatment options.

This study is novel in reporting the treatment outcomes of two adjacent implants in the maxillary central incisor region. Regarding the maxillary aesthetic zone in general, a randomized clinical trial by Tymstra et al.<sup>3</sup> described a 1-year survival rate of 100% for two adjacent implants when using a delayed implant placement and provisionalization protocol.

In the present study, inter-implant marginal bone loss was acceptable for all options and ranged from 0.21 to 1.16 mm. In comparison, Tymstra et al.<sup>3</sup> reported a mean 1-year inter-implant marginal bone loss of 0.9 mm (delayed implant placement, NobelReplace implants, Nobel Biocare AG). Loss of inter-implant bone crest was evident after extraction of the failing teeth (options 13) and continued after placement of the final implant restoration (options 13). This suggests that continuing inter-implant bone loss should

be expected after the extraction of failing teeth, regardless of the treatment protocol used.

The inter-implant papilla was best preserved when implants were placed using an immediate placement protocol (options 1 and 2), although a decrease in papilla fill was still observed after placement of the final implant restoration. Additionally, all options were associated with compromised inter-implant papilla fill after placement of the final implant restoration, which is in line with previous studies using adjacent implants in the maxillary aesthetic zone<sup>13</sup>.

The PES was scored the highest when implants were placed immediately (options 1 and 2), suggesting that additional surgical interventions and lower papilla index scores might negatively influence pink aesthetics. However, overall satisfaction was very high for all options. These findings might reflect patient satisfaction with a fixed dental solution instead of a removable partial denture. Similar patient satisfaction scores have been reported in earlier studies assessing the treatment outcomes of adjacent implants in the maxillary aesthetic zone<sup>1</sup>

□3.

A limitation of the case series presented here is the small number of patients. However, the clinical and radiographic results and the high patient satisfaction indicate that the treatment protocol proposed for two failing or missing central incisors in the maxillary aesthetic zone is an effective

guideline for clinicians on how to treat these patients.

In conclusion, based on the favourable clinical and radiographic results and the high patient satisfaction scores, the proposed implant treatment protocol for two failing or missing central incisors in the maxillary aesthetic zone could be considered a useful tool.

### Funding

The authors declare that no external funding sources were used in this research.

### Competing interests

No conflict of interest declared.

### Ethical approval

This case series study was not subject to the Medical Research Involving Human Subjects Act, but only to the Agreement on Medical Treatment Act. Treatment procedures were part of routine practices in the department, without randomization for the selection of the different treatments.

### Patient consent

Written patient consent was obtained from every patient for the possible use of clinical or radiographic photographs (only intraoral photographs) in any kind of material for publication.

### References

1. Van Nimwegen WG, Raghoobar GM, Stellingsma K, Tymstra N, Vissink A, Meijer HJ. Treatment outcome of two adjacent implant-supported restorations with different implant platform designs in the esthetic region: a five-year randomized clinical trial. *Int J Prosthodont* 2015;**28**:490–8. <http://dx.doi.org/10.11607/ijp.4199>.
2. Van Nimwegen WG, Raghoobar GM, Tymstra N, Vissink A, Meijer HJ. How to treat two adjacent missing teeth with dental implants. A systematic review on single implant-supported two-unit cantilever FDPs and results of a 5-year comparative study in the aesthetic zone. *J Oral Rehabil* 2017;**6**:461–71. <http://dx.doi.org/10.1111/joor.12507>.
3. Tymstra N, Raghoobar GM, Vissink A, Den Hartog L, Stellingsma K, Meijer HJ. Treatment outcome of two adjacent implant crowns with different implant platform designs in the aesthetic zone: a 1-year randomized clinical trial. *J Clin Periodontol* 2011;**38**:74–85. <http://dx.doi.org/10.1111/j.1600-051X.2010.01638.x>.
4. Kourkouta S, Dedi KD, Paquette DW, Mol A. Interproximal tissue dimensions in relation to adjacent implants in the anterior maxilla: clinical observations and patient aesthetic evaluation. *Clin Oral Implants Res* 2009;**20**:1375–85. <http://dx.doi.org/10.1111/j.1600-0501.2009.01761.x>.
5. Slagter KW, den Hartog L, Bakker NA, Vissink A, Meijer HJ, Raghoobar GM. Immediate placement of dental implants in the esthetic zone: a systematic review and pooled analysis. *J Periodontol* 2014;**7**:241–50. <http://dx.doi.org/10.1902/jop.2014.130632>.
6. Van Nimwegen WG, Goené RJ, Van Daelen AC, Stellingsma K, Raghoobar GM, Meijer HJ. Immediate placement and provisionalisation in the aesthetic zone. *J Oral Rehabil* 2016;**10**:745–52. <http://dx.doi.org/10.1111/joor.12507>.
7. Slagter KW, Meijer HJ, Bakker NA, Vissink A, Raghoobar GM. Feasibility of immediate placement of single-tooth implants in the aesthetic zone: a 1-year randomized controlled trial. *J Periodontol* 2015;**42**:773–82. <http://dx.doi.org/10.1111/jcpe.12429>.
8. Slagter KW, Meijer HJ, Bakker NA, Vissink A, Raghoobar GM. Immediate single-tooth implant placement in bony defects in the esthetic zone. A 1-year randomized controlled trial. *J Periodontol* 2016;**6**:619–29. <http://dx.doi.org/10.1902/jop.2016.150417>.
9. Pranskunas M, Poskevicius L, Juodzbaly G, Kubilius R, Jimbo R. Influence of peri-implant soft tissue condition and plaque accumulation on peri-implantitis: a systematic review. *J Oral Maxillofac Res* 2016;**3**:e2. <http://dx.doi.org/10.5037/jomr.2016.7302>.
10. Grunder U, Gracis S, Capelli M. Influence of the 3-D bone-to-implant relationship on the esthetics. *Int J Periodontics Restorative Dent* 2005;**25**:113–9.
11. Smeets EC, de Jong KJ, Abraham-Impijn L. Detecting the medically compromised patients in dentistry by means of the medical risk-related history. A survey of 29,424 dental patients in the Netherlands. *Prev Med* 1998;**27**:530–5. <http://dx.doi.org/10.1006/pmed.1998.0285>.
12. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. *J Prosthet Dent* 1989;**62**:567–72. [http://dx.doi.org/10.1016/0022-3913\(89\)90081-4](http://dx.doi.org/10.1016/0022-3913(89)90081-4).
13. Jemt T. Regeneration of gingival papillae after single-implant treatment. *Int J Periodontics Restorative Dent* 1997;**17**:326–33. <http://dx.doi.org/10.11607/prd.00.0224>.
14. Mombelli A, van Oosten MA, Schurch Jr E, Land NP. The microbiota associated with successful or failing osseointegrated titanium implants. *Oral Microbiol Immunol* 1987;**2**:145–51. <http://dx.doi.org/10.1111/j.1399-302X.1987.tb00298.x>.
15. Lo H, Silness J. Periodontal disease in pregnancy: I. Prevalence and severity. *Acta Odontol Scand* 1963;**21**:533–51.
16. Belser UC, Grutter L, Vailati F, Bornstein MM, Weber HP, Buser D. Outcome evaluation of early placed maxillary anterior single-tooth implants using objective esthetic criteria: a cross-sectional, retrospective study in 45 patients with a 2- to 4-year follow-up using pink and white esthetic scores. *J Periodontol* 2009;**80**:140–51. <http://dx.doi.org/10.1902/jop.2009.080435>.
17. Meijndert L, Meijer HJ, Stellingsma K, Stegenga B, Raghoobar GM. Evaluation of aesthetics of implant-supported single-tooth replacements using different bone augmentation procedures: a prospective randomized clinical study. *Clin Oral Implants Res* 2017;**18**:715–9. <http://dx.doi.org/10.1111/j.1600-0501.2007.01415.x>.

### Address:

W. G. van Nimwegen  
Department of Oral and Maxillofacial Surgery  
University Medical Center Groningen  
PO Box 30.001  
NL-9700 RB Groningen  
The Netherlands  
Tel.: +31 50 3613846  
E-mail: w.g.van.nimwegen@umcg.nl