

# Immediate versus Delayed Treatment in the Anterior Maxilla Using Single Implants with a Laser-Microtextured Collar: 3-Year Results of a Case Series on Hard- and Soft-Tissue Response and Esthetics

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## Keywords

Immediate implant treatment; delayed implant treatment; esthetic zone; laser-microtextured surface.

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## Abstract

**Purpose:** To compare peri-implant marginal bone loss, soft tissue response, and esthetics following single immediate implant treatment (IIT) and delayed implant treatment (DIT) in the esthetic zone of the maxilla in well-selected patients.

**Materials and Methods:** Adequate bone volume and ideal soft tissue level/contour were considered requirements for implant therapy, with additional prerequisites for IIT of residual alveolar bone wall integrity and a thick gingival biotype. IIT included immediate placement and provisionalization, while DIT included extraction socket preservation followed by implant placement and provisionalization 4 months later. Cortical bone levels and peri-implant mucosal conditions were evaluated at regular intervals. The esthetic outcome was objectively rated after 3 years using the pink esthetic score (PES) and white esthetic score (WES).

**Results:** Twelve patients received an immediate Laser-Lok® implant, and 13 patients received a delayed Laser-Lok® implant. No significant differences were found between the study groups regarding survival rate (100%). The mean bone level from the implant/abutment interface was  $0.35 \pm 0.18$  mm for IIT and  $0.42 \pm 0.21$  mm for DIT after 3 years ( $p > 0.05$ ). Mesial and distal papillae remained stable over time in DIT. A tendency for regrowth of mesial and distal papillae was found following IIT ( $p < 0.05$ ). Midfacial soft tissues remained stable over time following DIT and IIT.

**Conclusions:** Within the limitations of this study (e.g., small sample size, short follow-up duration), the results suggest that regarding success rate, hard/soft tissue responses, and esthetics, DIT and IIT with single Laser-Lok® implants in the anterior maxilla are comparable and predictable options for well-selected patients.

Traditionally, dental implants have been placed using a two-stage surgical protocol, which recommended complete healing of the alveolar bone after tooth extraction, and a healing period of 3 to 6 months before loading.<sup>1</sup> Improved knowledge in the therapeutic use of dental implants has led to radical changes in the traditional guidelines for implant therapy. Immediate placement of implants in fresh extraction sites and reduction of the load-free period by immediately restoring implants are techniques gradually gaining in popularity.<sup>2</sup> A growing amount of data indicates a treatment protocol of tooth extraction combined with immediate implantation and immediate loading can be carried out successfully in cases of single-tooth replacement in the esthetic zone.<sup>3-6</sup> One of the advantages of this protocol is that it significantly reduces the number of surgical procedures and eliminates the need for a temporary prosthesis between surgery and prosthetic rehabilitation. Despite the favorable results reported in the literature, this treatment in esthetic

zones may be a risky procedure in terms of soft-tissue stability, especially when patients are improperly selected.

Data from the literature suggest that single-implant-supported immediate restoration, replacing single extracted teeth in the esthetic zone with natural adjacent teeth, represents a predictable and successful treatment procedure for implant survival. But with reference to other parameters, such as soft-tissue response and esthetics, the impact of this treatment strategy remains controversial.<sup>7</sup> When planning an implant in an extraction socket, three approaches have been proposed to clinicians:<sup>8,9</sup>

1. immediate implant placement at the time of extraction (type 1);
2. early implant placement following a few weeks of soft-tissue healing before implant insertion (type 2);

3. delayed implant placement, when implants are placed in a postextraction site with partial bone healing and healed soft tissues, typically 12 to 16 weeks after extraction (Type 3).

Similar survival and success rates of single-tooth implants have been achieved for all three implant placement approaches,<sup>10-12</sup> although immediate implants failed to prevent resorption of the alveolar buccal bone structure and the remodeling of soft peri-implant tissue, especially in the buccal marginal sector.<sup>13,14</sup> Additionally, tissue remodeling and buccal bone plate resorption occurred whether or not concomitant regenerative procedures were used.<sup>15-17</sup> However, the amount of peri-implant tissue alteration seems to be determined by many factors, including the moment of implant placement relative to tooth extraction,<sup>18-21</sup> variations in the surgical technique<sup>22</sup> and restorative procedure,<sup>23-26</sup> preexisting defects of the facial bone,<sup>27</sup> tissue biotype,<sup>28</sup> implant malposition,<sup>28-30</sup> thickness of the facial bone,<sup>15</sup> and biomaterials used.<sup>15,31</sup> Due to the heterogeneity of these factors, more prospective studies over longer time periods and encompassing a larger number of observers and a larger number of implants are needed. The literature comparing the efficacy of type 1 and 2 protocols with the standard type 3 protocol in the esthetic zone has been reviewed and analyzed.<sup>32-35</sup> From the available data, firm conclusions cannot be drawn regarding the most preferable treatment strategy. Contradictions between the reported data are connected not only with regard to study design and methodology (surgical and grafting techniques, and loading protocols used), but also in regard to the definitions of the study groups and the outcome variables.<sup>34</sup> Therefore, the clinical impact of single implant placement in fresh extraction sockets of the anterior maxilla, according to type 1, 2, and 3 protocols, must continue to be investigated, especially in terms of stability over time and soft-tissue maintenance.

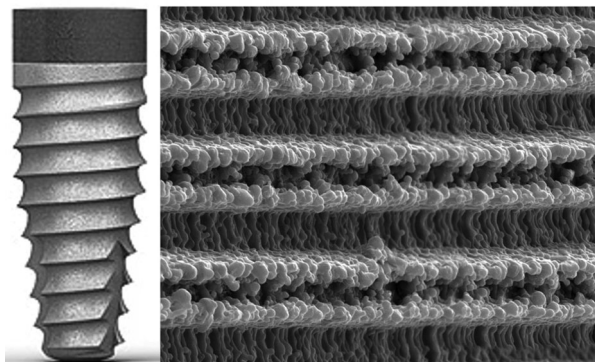
The primary goal of this clinical study was to assess the hard and soft tissue dimensional changes following single immediate implant treatment (IIT) and delayed implant treatment (DIT) in the esthetic area of the maxilla in well-selected patients using an implant with a laser microtextured collar surface. The secondary objective was to document the esthetic outcome of IIT and DIT using objective criteria.

## Materials and methods

This research study used a retrospective clinical database that involved collecting information about patients who were previously treated either as part of an approved research protocol or as part of routine care using accepted therapy for each patient's specific clinical needs. Since investigators did not have access to identifiable private information, this research did not require approval by an institutional ethics board or committee. All patients provided informed consent to participate in this study, and treatments were performed according to the principles outlined in the Declaration of Helsinki on experimentation involving human subjects.

### Implants

In this study, single Tapered Internal Laser-Lok<sup>®</sup> implants (BioHorizons, Birmingham, AL) were used. The body of the



**Figure 1** (Left) Laser-Lok<sup>®</sup> Tapered Internal Implant; (Right) high magnification (7000 $\times$ ) of collar surface.

implant had been blasted with resorbable blast media to create a surface roughness between 0.72 and 1.34  $\mu\text{m}$ , whereas the implant neck was composed of a 1.8-mm laser-ablated microgrooved surface (8  $\mu\text{m}$ ; Fig 1).

### Patient selection

To be included in the study, the following criteria had to be fulfilled:

1. Age > 18 years.
2. Presence of a single hopeless tooth in the anterior maxilla (teeth #15–25) with presence of teeth adjacent to the implant area (mesially and distally).
3. Ideal soft tissue level/contour, and adequate bone volume as evaluated by standard radiographs or CT scans to obtain primary implant stability.
4. Signed informed consent.

Patients were excluded on the basis of:

1. pregnancy at the time of inclusion;
2. presence of relevant medical conditions contraindicating surgical interventions;
3. full mouth plaque score (FMPS)  $\geq$  25%;<sup>36</sup>
4. under treatment or treated with intravenous aminobiphosphonates;
5. heavy smokers ( $\geq$ 20 cigarettes daily); and
6. nontreated periodontal diseases and/or caries.

Additional exclusion criteria for patients treated with immediate implants were the lack of total integrity of the alveolar walls, and the presence of a thin-scalloped gingival biotype, determined using the probe transparency method as described by De Rouck *et al*<sup>37</sup> To be included in the study, implants had to attain a minimal peak insertion torque of 35 Ncm, regardless of the treatment protocol.

### Clinical procedures

Indications for tooth extraction and implant placement included trauma, root fractures, endodontic failure, nonrestorable crowns, and the presence of deciduous teeth in cases of tooth agenesis (Table 1). Radiolucency at the apex, without signs of activity (pain, fistula, redness, and suppuration) was also included in the indications. A complete examination of the

**Table 1** Reasons for tooth loss sorted per treatment strategy

Treatment strategy	Reasons for tooth extraction					Total
	Agenesis	Fracture	Caries	Periodontal endodontic	Root resorption	
IIT	1	3	5	N/A	3	12
DIT	N/A	2	4	4	3	13
Total	1	5	9	4	6	25

IIT, immediate implant treatment; DIT, delayed implant treatment.

oral hard and soft tissues was carried out for each patient, and the implant placement was planned based on clinical and radiographic evaluation. Immediate implants were placed at the time of tooth extraction, while delayed implants were placed 4 months after tooth removal. One gram of amoxicillin was administered 1 hour before surgery. A chlorhexidine digluconate 0.2% rinse was used immediately before surgery. Both were continued for 5 to 7 days postsurgery. After local anesthesia was obtained by infiltrating articaine 4% containing 1:100,000 epinephrine (UbistesinR; 3M ESPE, St. Paul, MN), no flaps were designed, and no incisions were made. Teeth were carefully removed to preserve the integrity of the alveolar bone walls, and the sockets debrided. A periodontal probe was used to evaluate the internal surface of the alveolus for dehiscences and fenestrations before implant placement.

### Immediate implant group

In this group, clinical procedures were conducted as in our previous report<sup>38</sup> as follows: the distance between the gingival margin and the bone was measured with a periodontal probe. This distance was added to the desired implant length, and the buccal gingival margin served as the height reference point. The longest and widest possible implants were placed. The implant was inserted at the most coronal part of the alveolar crest, and special attention was paid to the three-dimensional positioning of the implant as described by Buser *et al*<sup>39</sup> Final implant position was carried out using a torque driver (Precise Adjustable Torque Wrench; BioHorizons). The distance between the coronal part of the implant and the gingival margin was used to choose the healing abutment height. There was no need for suturing in any site.

An interim resin crown in methyl methacrylate was made on the temporary abutment and was connected to the implant within 12 hours of implant placement. Special care was taken to prevent any centric and eccentric contacts on the interim crowns. The interim prostheses remained in situ for 4 months, and after this period, definitive restorations were placed (Fig 2).

### Delayed implant group

Patients assigned to the DIT group had teeth extracted and the sites grafted. After debridement, the socket was filled with 0.50 to 1 g of anorganic bovine bone granules (Laddec®; BioHorizons). The graft particles were firmly packed into the extraction site and covered with a cross-linked collagen membrane (Mem-Lok®; BioHorizons). Sutures were placed to adapt the gingiva to the membrane. Four months after tooth

extraction, surgical access was carried out by a full-thickness flap at the level of the keratinized mucosa to minimally extend the release incision and expose the crest and the vestibular limit of the bone. Implants were placed in the regenerated sites and immediately provisionalized following the prosthetic procedures described for the IIT. The definitive restorations were delivered 4 months after implant placement in all the patients (Fig 3).

### Clinical follow-up examination

All patients were recalled every 6 months for professional oral hygiene. Every year during the recall visit, the following parameters were considered: presence or absence of pain observed with palpation, percussion, or function; presence or absence of infection; presence or absence of fixture mobility; and presence or absence of prosthetic complications at the implant/abutment interface. Moreover, intraoral periapical radiographs were taken at the baseline (immediately after implant insertion) and at the 1-, 2-, and 3-year follow-up sessions using a paralleling technique (Dentsply RINN, Elgin, IL). A silicone index material, fixed to the dentition, was used for precise repositioning, and a radiograph holder was constructed for each patient. As described in our previous report,<sup>38</sup> the radiographic examination was performed as follows: the radiographs were digitized using a dedicated scanner (HP 3000; Hewlett-Packard, Palo Alto, CA) with a resolution of 2048 × 3072 lines and converted into JPG files. A software package (AutoCAD 2000; Autodesk Inc., San Rafael, CA) was used to measure marginal bone loss. Vertical lines were drawn from the top of the implants to the marginal bone to measure the marginal bone level (MBL). MBL was calculated as the difference in MBL at 3-year follow-up from the baseline. To correct for dimensional distortion in the radiograph, the digitized images were scaled to compare the apparent and the true dimension of each implant (Figs 3 and 5).

### Esthetic follow-up examination

To objectively examine the esthetic outcome of the implants, we used the same clinical operative protocol described by Mangano *et al*<sup>40</sup> as follows: intraoral photographs were taken with a digital camera (D100R; Nikon, Tokyo, Japan) and a 105 mm lens (AF micro Nikkor 105 mm 1:2.8 D; Nikon) with a ring flash (Nikon Macro Speedlight SB-29S, Nikon, Tokyo, Japan), and critically analyzed by means of the Pink Esthetic Score Index (PES)<sup>41</sup> and White Esthetic Score Index (WES),<sup>42</sup> by an independent calibrated observer, who was not directly involved in the study. For the central and lateral tooth evaluations, the photographs were centered at the midline to ensure symmetric comparability with the reference contralateral tooth. In addition, standardized clinical photographs of each single implant site and of the contralateral tooth were used as tools for more detailed comparisons. For the canine and first premolars involved in the study, the photographs were not taken at the midline but with these teeth as references. Photographs were then viewed on a 42-inch monitor screen (Samsung PPM-42S3Q Flat Panel Plasma MonitorR; Samsung, Seoul, South Korea). For each patient involved in the study, the clinical photographs and the study casts fabricated in type IV stone were used to perform the esthetic evaluations by means of the PES/WES index.



**Figure 2** Example of IIT. (A) clinical situation; (B) facial view of the extraction socket; (C) buccal view of the extraction socket; (D) implant placement; (E) facial views of immediate interim prosthesis; (F) facial views of interim crown after 4 months (H) facial views of tissue at definitive restoration delivery; (I) buccal views of tissue at definitive restoration delivery; and (J) facial views of definitive restoration after 3 years.

To reduce bias and to achieve good reproducibility, the evaluation was carried out twice, 1 day apart; in case of diverging scores, the observer carefully reevaluated the photographs before making his final decision.

The seven variables of PES (mesial papilla, distal papilla, midfacial level, midfacial contour, alveolar process deficiency, soft tissue color, and soft tissue texture), and the five variables of WES (tooth form, tooth volume, tooth color including the assessment of hue and value, tooth texture, and translucency), were used to evaluate, after 3 years, the esthetic outcome of the peri-implant soft tissue, and the esthetic outcome of the visible part of the implant restorations, respectively. Each variable is assigned a score of 0–1–2 (2 the best, 0 the worst). PES and WES scores, as proposed by Cosyn *et al*,<sup>5</sup> were taken into consideration for the evaluation as follows: a score of 6 out of 10 was considered acceptable, and a score of 9 out of 10 was considered perfect or almost perfect. The combination of the results of the PES and WES was used for the overall esthetic evaluation as follows: if PES  $\geq$  12 and WES  $\geq$  9, the treatment was considered perfect or almost perfect. If PES < 8 and/or WES < 6, the result was considered a failure.

### Success rating

Criteria for success include absence of fixture mobility and absence of peri-implant radiopacity/radiolucency at radiograph assessment, absence of suppuration, pain, infection, and paresthesia. Failure was defined as removal of an implant for any reason.

### Statistical analysis

The patient was used as the statistical unit in all analyses. The Mann-Whitney test was used to compare the overall PES/WES, PES, and WES between immediate and delayed implant placement. The level of significance was set at 0.05. All the results were expressed as mean  $\pm$  standard deviation.

### Results

Twelve patients (7 men, 5 women; mean age 42) received an immediate implant, whereas 13 patients (8 men, 5 women; mean age 40) received a delayed implant. No patient was dropped from the study due to lack of final torque. The reasons



**Figure 3** Example of IIT. Periapical radiographs immediately after temporary restoration (BSL) and after 3 years.

**Table 2** Implant position sorted per treatment strategy

Treatment strategy	Implant position				Total
	Central incisor	Lateral incisor	Cuspid	Premolar	
IIT	5	4	1	2	12
DIT	4	4	1	4	13
Total	9	8	2	6	25

IIT, immediate implant treatment; DIT, delayed implant treatment.

**Table 3** Implant length and diameter sorted per treatment strategy

Treatment strategy	Diameter (mm)	Length (mm)				Total
		9	10.5	12	15	
IIT	3.8	0	0	0	0	0
	4.6	1	3	6	1	11
	5.8	0	1	0	0	1
DIT	3.8	0	1	1	0	2
	4.6	2	4	5	0	11
	5.8	0	0	0	0	0
Total		3	9	12	1	25

IIT, immediate implant treatment; DIT, delayed implant treatment.

for tooth extraction are shown in Table 1. Caries and endodontic lesions were the most frequent causes for tooth extraction. Implant positions are summarized in Table 2. Overall, central and lateral incisors had to be replaced most often. Table 3 shows the implant lengths and diameters sorted per treatment strategy.

**Implant success and hard tissue response**

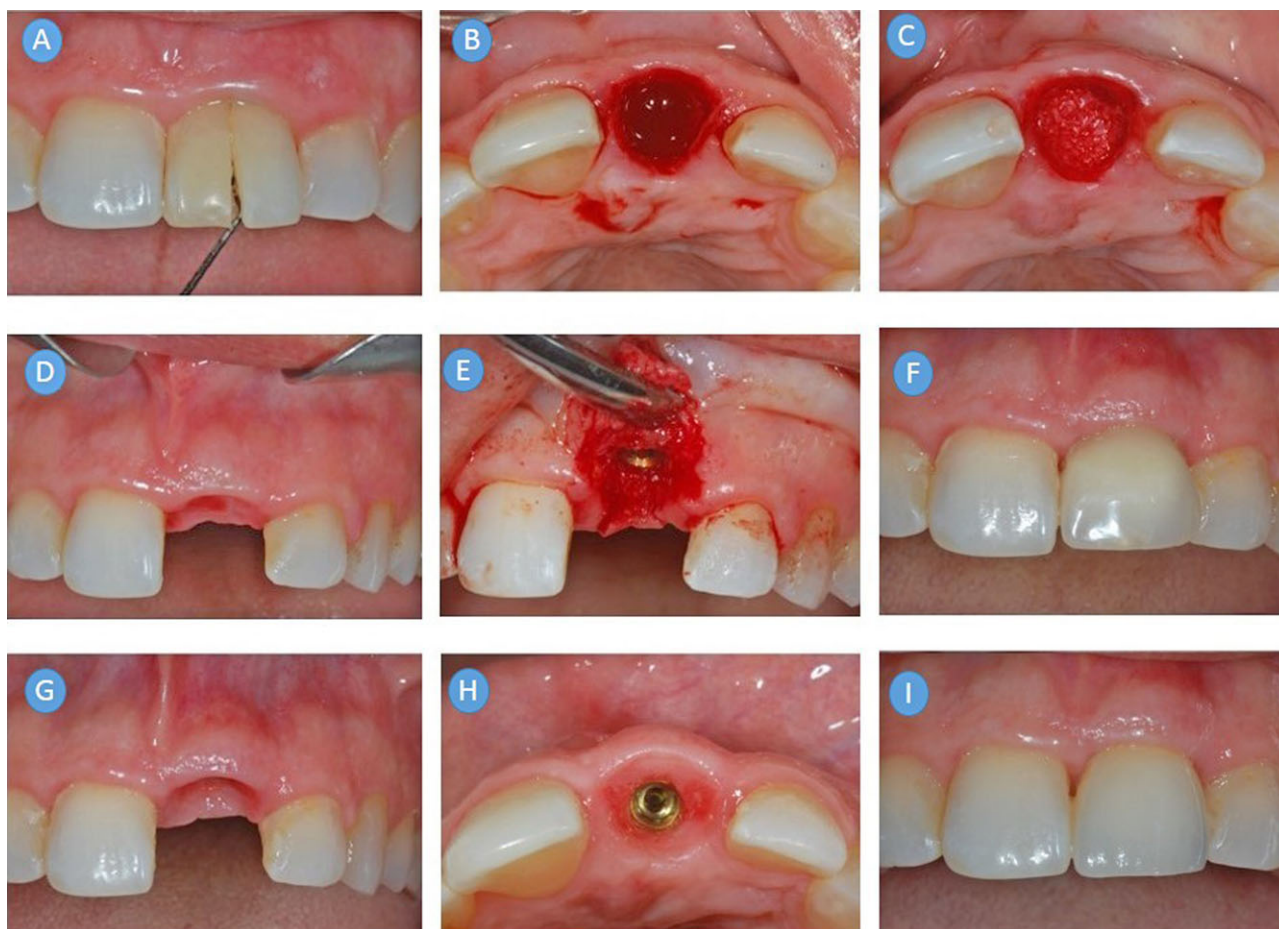
All implants fulfilled the success criteria, with an implant-crown success rate of 100.0%, regardless of the treatment group. The mean MBL from the implant/abutment interface was  $0.35 \pm 0.18$  mm for IIT and  $0.42 \pm 0.21$  mm for DIT after 3 years ( $p > 0.05$ ).

**Soft tissue response**

The differences in mesial and distal papilla height and mid-facial level, observed at the baseline and at 3-year follow-up are illustrated in Table 4. At 3-year follow-up examination, the level of mesial and distal papillae was stable in DIT. A tendency for regrowth of mesial ( $0.41 \pm 0.61$  mm) and distal ( $0.35 \pm 0.83$  mm) papillae was found following IIT. A significant statistical difference for mesial and distal papillae in the IIT group ( $p < 0.05$ ) was observed between baseline and 3-year follow-up. Midfacial soft tissues remained almost stable over time following DIT and IIT, with a minimal mean recession of 0.06 mm in IIT, and of 0.02 in DIT.

**Esthetics**

Tables 5 and 6 show the results of all criteria of the PES per treatment strategy. The mean PES was 11.06 (0.63), and 11.81 (0.55) for IIT and DIT, respectively, whereas the mean WES was 7.32 (0.71), and 7.53 (0.74) for IIT and DIT, respectively. In the IIT group, the mesial papilla level and soft tissue were most satisfying, showing a perfect match with the corresponding tooth in 9/12 (75%) and 10/12 (83%) patients, respectively.



**Figure 4** Example of DIT. (A) clinical situation; (B) buccal view of the extraction socket; (C) graft material positioned in the extraction socket; (D) tissue healing after 4 months; (E) implant placement; (F) facial views of interim prosthesis 1 month later; (H) facial views of tissue at the delivery of definitive restoration; (I) buccal views of tissue at the delivery of definitive restoration; and (J) facial view of restored implant after 3 years.

**Table 4** Soft tissue responses sorted per treatment strategy

Treatment strategy		1 year	2 years	3 years
Mesial papillae	IIT <sup>†</sup>	0.16 (0.71) (-2; 0.5)	0.39 (0.68) (-2; 1)	0.41 (0.61) (-1; 0.5)
	DIT	-0.04 (0.70) (-1.1; 1.4)	-0.10 (1.20) (-1.65; 2.0)	-0.11 (0.65) (-1.8; 2.1)
Distal papillae	IIT	0.28 (0.78) (-2; 1.1)	0.30 (1.20) (-1.65; 2.0)	0.35 (0.83) (-1.2; 2.0)
	DIT	-0.14 (0.76) (-1.1; 1.4)	-0.09 (0.41) (-1; 2)	-0.06 (0.62) (-1.2; 1.9)
Midfacial level	IIT	-0.14 (0.76) (-1.7; 0.5)	-0.08 (0.60) (-1.5; 1.0)	-0.06 (0.61) (-1.2; 1.1)
	DIT	-0.04 (0.13) (-0.5; 0.2)	-0.02 (0.18) (-0.3; 0.6)	-0.02 (0.11) (-0.4; 0.3)

IIT, immediate implant treatment; DIT, delayed implant treatment.

Mean in mm (SD; range); negative value, soft tissue loss relative to baseline (provisional crown installation); positive value, soft tissue gain relative to baseline.

<sup>†</sup>Significant within group difference between baseline (provisional crown installation) and 3 years.

Unfavorable results were most prevalent for the midfacial level and midfacial contour, showing severe deficiency in 1/12 (8.3%) patients. In the DIT group, soft tissue texture, and soft tissue color (11/13, 84%) showed the best value, while midfacial level, midfacial contour level, alveolar process, and soft tissue texture showed unfavorable results in 1/13 (7%) patients. The overall esthetic outcome was assessed by combining the

results of the PES and WES. In the IIT group, 4 out of 12 (33%) single implant treatments showed an almost perfect result (PES ≥ 12 and WES ≥ 9); 6 out of 12 (50%) showed an acceptable result (PES: 8–11 and WES: 6–8); and 2 out of 12 (17%) showed an unfavorable esthetic outcome. In the DIT group, 4 out of 13 (31%) single implant treatments showed an almost perfect result (PES ≥ 12 and WES ≥ 9); 8 out of 13 (61%)

**Table 5** Summarized esthetic outcome at 3 years sorted per treatment strategy

Parameter PES	Immediate implant treatment (n = 12)			Delayed implant treatment (n = 13)			Significance between groups
	Value 0	Value 1	Value 2	Value 0	Value 1	Value 2	<i>p</i>
Mesial papilla	0	3	9	0	4	9	0.478
Distal papilla	0	4	8	0	4	9	0.309
Midfacial mucosa level	1	5	6	1	3	9	0.165
Midfacial contour	1	5	6	1	3	9	0.165
Alveolar process deficiency	1	3	8	1	3	9	0.309
Soft tissue color	1	1	10	0	2	11	0.227
Soft tissue texture	1	2	9	1	1	11	0.124

Parameter WES	Immediate implant treatment (n = 12)			Delayed implant treatment (n = 13)			Significance
	Value 0	Value 1	Value 2	Value 0	Value 1	Value 2	<i>p</i>
Tooth form	2	3	7	2	3	8	0.429
Tooth volume	1	4	7	1	4	8	0.383
Tooth color	2	3	7	3	1	9	0.314
Tooth texture	1	4	6	2	2	9	0.414
Translucency	1	3	7	2	2	9	0.414

**Table 6** Summarized PES and WES at 3 years sorted per treatment strategy

Immediate implant treatment PES								
	Mesial papilla	Distal papilla	Midfacial mucosa level	Midfacial contour	Alveolar process deficiency	Soft tissue color	Soft tissue texture	Total score
Maximum	2	2	2	2	2	2	2	14
Minimum	1	1	0	0	0	0	0	2
Mean	1.75	1.66	1.41	1.41	1.58	1.75	1.66	11.06
SD	0.45	0.49	0.66	0.66	0.66	0.62	0.65	0.63

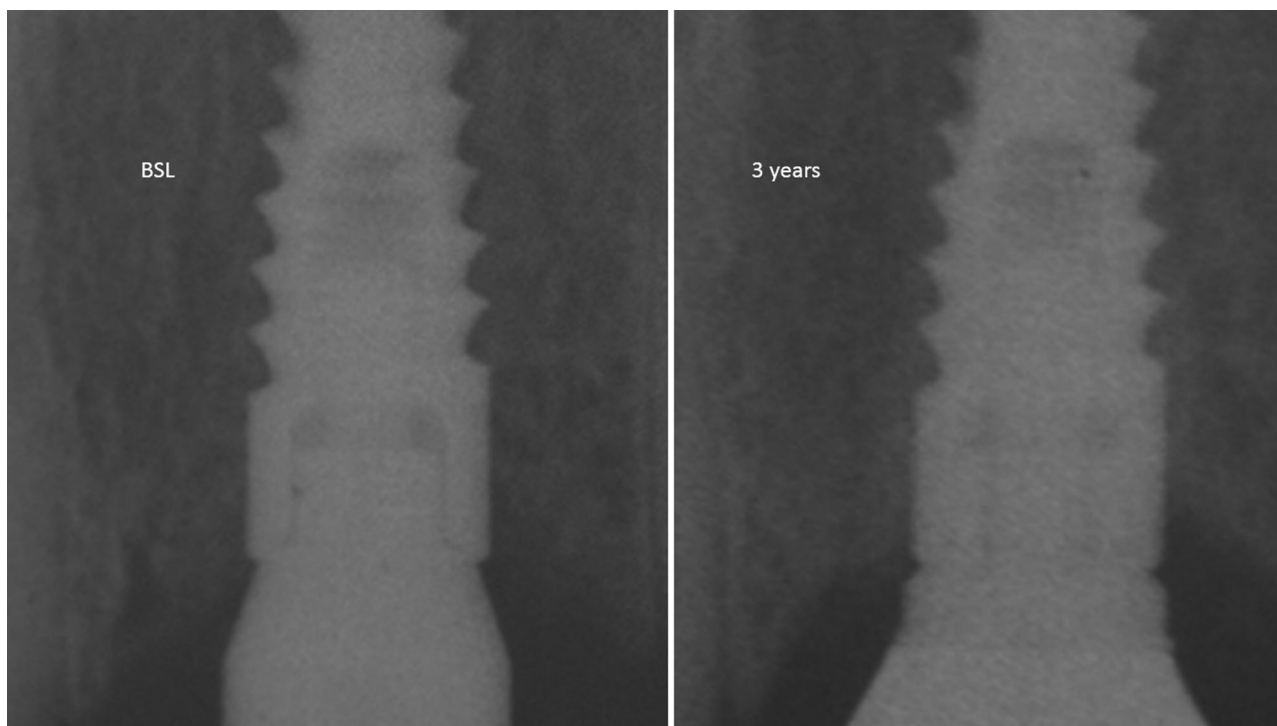
Delayed implant treatment PES								
	Mesial papilla	Distal papilla	Midfacial mucosa level	Midfacial contour	Alveolar process deficiency	Soft tissue color	Soft tissue texture	Total score
Maximum	2	2	2	2	2	2	2	10
Minimum	1	1	0	0	0	0	0	2
Mean	1.69	1.69	1.61	1.61	1.61	1.76	1.84	11.81
SD	0.48	0.48	0.65	0.65	0.65	0.59	0.37	0.55

Immediate implant treatment WES						
	Tooth form	Tooth volume	Tooth color	Tooth texture	Translucency	Total score
Maximum	2	2	2	2	2	10
Minimum	0	0	0	0	0	0
Mean	1.41	1.5	1.41	1.5	1.5	7.32
SD	0.79	0.67	0.79	0.67	0.67	0.71

Delayed implant treatment WES						
	Tooth form	Tooth volume	Tooth color	Tooth form	Translucency	Total score
Maximum	2	2	2	2	2	10
Minimum	0	0	0	0	0	0
Mean	1.41	1.53	1.53	1.53	1.53	7.53
SD	0.77	0.66	0.77	0.77	0.77	0.74



**Figure 5** Example of DIT. Periapical radiographs immediately after temporary restoration (BSL) and after 3 years.

showed an acceptable result (PES: 8–11 and WES: 6–8), and 1 out of 13 (8%) showed an unfavorable esthetic outcome.

## Discussion

In this study, 100% of the implants survived after 3 years of function, regardless of the treatment strategy used (IIT or DIT). These results are in agreement with published data<sup>32</sup> reporting no difference in survival rate, relative to tooth extraction in the esthetic zone, between single implants immediately placed and loaded, and implants conventionally installed after a comparable observation time.<sup>43,44</sup> However, in the esthetic zone, the long-term quality of the success of single-implant therapy also depends on several other factors (including esthetics) closely related to the maintenance of MBL. The level of peri-implant marginal bone is considered a determining factor in evaluating the quality of survival (and thus of primary outcome) because marginal bone determines the level of the peri-implant mucosa, and thus the esthetic outcome.<sup>45-47</sup> Moreover, the resorption of the marginal bone may favor pocket formation, which could compromise the long-term stability of the peri-implant tissues.<sup>48</sup> Previous clinical studies have shown that implants with a laser microtextured collar surface provide opportunities for limited bone remodeling.<sup>49-52</sup> Results of this study confirm this data, (mean bone loss after 3 years of function of  $0.35 \pm 0.18$  mm for IIT, and  $0.42 \pm 0.21$  for DIT), without statistically significant differences between the two treatment strategies.

The fact that implants with a laser microtextured collar reduce crestal bone loss could also be an explanation for the

peri-implant tissue condition results observed in both study groups. Following DIT, mesial and distal papillae remained stable from baseline examination (temporary crown delivery) to 3-year follow-up examination, while following IIT, a mean gain of 0.40 mm and of 0.35 mm was found for mesial papilla and distal papilla, respectively. In both study groups, complete embrasure fill in was seen in about 70% of the patients at 3 years. This is in agreement with previous findings that the filling of papillae is independent of the timing of the implant surgery relative to tooth extraction.<sup>18,53</sup> In fact, the height of interdental papilla depends on the bone level next to the adjacent teeth, and that proximal bone level is not influenced by the timing of implant placement.<sup>54-57</sup> Our data showed that midfacial soft tissue levels remained fairly stable over time regardless of the treatment strategy. This seems contrary to the conclusion of a literature review that showed that type 1 placement is connected to a high risk of midfacial mucosa recession.<sup>58</sup> However, other reviews reported limited risk for advanced midfacial recession following type 1 implant placement in cases of intact buccal wall and thick gingival biotype.<sup>59-61</sup> The low incidence of advanced midfacial recession in IIT from this study may also be related to the strict inclusion criteria we adopted. In all selected patients, extraction sites had to demonstrate an ideal hard and soft tissue level/contour. In addition, the most frequent reasons for extraction in this study were endodontic failures, which usually led to bone loss in the apical rather than in the marginal alveolar area.

The sample size of this study is too small to demonstrate whether IIT, compared to DIT, may allow for the preservation of the midfacial soft tissue, and further studies are needed. In



light of the significant influence the laser microtextured collar surface has on marginal bone loss, one could also justify the additional effect this kind of collar surface may have on the level of the peri-implant mucosa. The influence of the implant collar surface on marginal bone loss around implants has been discussed only recently, and has received little attention in comparison to other factors.<sup>62,63</sup> Recent studies reported that the creation of microthreads and microgrooves on the implant neck might limit marginal bone resorption.<sup>64-66</sup> Some *in vitro* studies<sup>67,68</sup> evaluating the effect of surface microgeometry with respect to attachment, spreading, orientation, and growth of fibroblasts, showed that cultured fibroblasts grown on microgrooved surfaces become oriented and channeled in line with the grooves, while cells grown on nongrooved surfaces showed random growth. Furthermore, laser-ablated microgrooves promote oriented cell filipodial contact and fibrin fibril orientation.<sup>69</sup> These *in vitro* results have provided the hypothesis that laser-microtextured surfaces could be used to control soft tissue responses to implant surfaces. It has been suggested that laser-produced microgrooves on implant collars could be used to create a predetermined site on which a physical connective tissue attachment can be achieved. Histological research in an animal model<sup>70</sup> and in humans<sup>71</sup> has subsequently confirmed this hypothesis, documenting the presence of a physical connective tissue attachment onto laser-produced microgrooves on implant and abutment surfaces. The most important aspects of this physical connective tissue attachment have been identified. Its position is determined by the laser microgroove layout; the connective tissue fibers are perpendicularly oriented to the implant surface, and these fibers act by sealing out contaminants in the external environment.

Based on these data, one might speculate that repetitive nano-size surface features created with a laser on the implant collar have the ability to allow fibroblasts to form a physical connective tissue attachment. As is the case of natural teeth, in which collagen bundles inserted into the root cementum deter the downgrowth migration of the overlying epithelium, epithelial downgrowth around implants could be impeded by firm physical attachment between the soft connective tissue and the implant. The laser-microtextured surface, while not analogous to the cemental surface of the natural teeth, seems to act by promoting the formation of a physical connective tissue attachment that restricts the downgrowth of epithelium, and thus provides a soft tissue support in addition to that provided by the marginal bone.

In a preclinical histological animal research, Shin and Han<sup>72</sup> used immediate implant placement in fresh extraction sockets to study the impact of a laser-microtextured collar design on soft- and hard-tissue healing. In the microgrooved group at both the buccal and the lingual aspects, the histologic findings documented the presence of a physical connective tissue attachment onto the laser-created microgrooves. Moreover, 12 weeks after the implantation, the microgrooved group showed a mean bone/implant contact significantly higher than the turned surface group, and an epithelium downgrowth to where the connective tissue fibers were physically connected to implant surface. The turned surface group instead showed an epithelium downgrowth that extended over the turned surface up to the point where the thread began. To date, there is no histomor-

phometric comparative evidence in humans on these treatment concepts. Therefore, it is difficult to assess how these findings relate to our clinical results. What is clear on the basis of this study, however, is the risk for advanced midfacial recession was clearly low in our patients, regardless of the treatment strategy adopted. To our knowledge, only a few studies have reported mean PES and WES values following type 1 implant placement compared with type 3 implant placement,<sup>72-74</sup> and none of these reported a significant difference between type 1 and type 3 groups. Felice *et al*<sup>73</sup> reported the highest mean PES values both in type 1 and in type 3 groups (12.75 vs. 12.62). Cosyn *et al*<sup>74</sup> reported a mean value of 10.88 and of 10.07, while the mean values reported by Raes *et al*<sup>75</sup> were 10.33 and 10.35, respectively, for type 1 and type 3 treatment strategies. Our results are in agreement with these data (mean PES was of 11.06 for IIT and 11.81 for DIT), and they confirm that, in the short term, the peri-implant soft tissue response did not show significant differences following IIT and DIT with well-selected patients. The main limitation of this study is that it was not designed as a randomized trial. Another limitation of this investigation is the small sample size. For these reasons, final confirmation of these findings and of related suggestions put forward in this paper will require longer periods of observation with an increased number of implants.

## Conclusion

Within the limitations of this study, for success rate, hard/soft tissue responses, and esthetics, DIT and IIT with single Laser-Lok<sup>®</sup> implants in the anterior maxilla seem comparable and predictable options for well-selected patients.

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