

Single-Tooth Replacement in the Anterior Maxilla by Means of Immediate Implantation and Early Loading: Clinical and Aesthetic Results at 5 Years

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ABSTRACT

Background: The hypothesis of the present study was that the early loading of single implants-supported restorations, replacing single extracting teeth in the anterior region of the maxilla in case of fresh extraction sockets with residual hard and soft tissue preservation, could be a successful procedure.

Methods: Twenty-one implants were placed into maxillary anterior fresh extraction sockets using a flapless technique. Temporary restorations, which were fabricated from the impression taken immediately after implant placement, were connected within 2 weeks. These temporary restorations were adjusted in order to avoid any direct occlusive contacts. Six months after implantation, the implants were restored with single-teeth all-ceramic prostheses. Patients were followed for 5 years. Radiographic and clinical examinations were made at baseline, at time of definitive crowns delivery, and each subsequent year. Survival rate, cortical bone responses, and peri-implant mucosal responses were evaluated.

Results: One implant was lost at 6 months. Clinical osseointegration of 20 implants was achieved (95.2% implant survival rate after 5 years) with minimal gingival recession and papillae preservation. The mean change in marginal cortical bone level was 0.40 mm at 6 months and 0.83 mm at 5 years.

Conclusions: Within the limit of the present study, the data indicate that, under a strictly controlled oral hygienic regimen, single-tooth implants, with immediate placement and early loading protocol, may be used in anterior maxillary fresh extraction sockets with residual hard and soft tissues preservation, if patients are selected carefully and if high primary stability is strictly followed.

KEY WORDS: early loading, extraction sockets, immediate implant placement

INTRODUCTION

A prerequisite for successful implant treatment is the achievement and maintenance of osseointegration, defined as a “direct contact between living bone and load-carrying endosseous implant.”¹ As described by Adell and colleagues,² osseointegration is dependent on fundamental factors that include biocompatibility, primary stability assured by implant design and surface

characteristics, careful surgical technique, and the state of the host. Another factor affecting osseointegration is time. Brånemark’s origin protocols¹ recommend complete healing of the alveolar bone before placing an implant after tooth extraction, and a healing period of 3 to 6 months before loading the implant. However, the healing time that is necessary before implant can be placed in function has been proposed as a result of clinical observation rather than biological documentation. The reduction of healing time using immediate implant placement into fresh extraction sockets has been described and proposed in several studies showing comparable survival rates to implants placed in according to the original protocol.^{3,4} Besides immediate implantation, the time may be further optimized by reducing or even eliminating the load-free healing period following implant placement. Several investigation

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have demonstrated successful immediate loading for implants-supported fixed cross-arch splinted superstructure,⁵ supported multiunit reconstructions,^{6,7} and also supported single-tooth restorations.^{8,9} Advances in biomaterials and clinical techniques have further facilitated significant expansion in the indications for dental implant therapy, and in contemporary implantology, installation of implants in fresh extraction sockets and reducing the load-free period by immediate restoring implants after insertion have been adopted.¹⁰ Today, a growing evidence of data indicates that a treatment protocol involving tooth extraction immediately combined with implant placement and loading can be carried out successfully also in patients with a hopeless maxillary anterior teeth.¹¹ However, immediate single implant treatment in maxillary esthetic zones may be a risky procedure in terms of soft tissue stability especially when patients are improperly selected.^{12,13}

The purpose of the present study was to document in the long term the overall outcome of early loading of implant-supported restorations replacing single extracting teeth in presence of soft and hard tissue preservation in the anterior maxilla focusing on survival rate, crestal bone loss, and soft tissue dynamics and aesthetic aspects.

MATERIALS AND METHODS

Patients

Twenty-one patients (14 males and seven females) ranging age from 22 to 40 years (mean 34 years) were selected for the placement of 21 implants in fresh anterior maxilla extraction sockets with early loading. They were in a good general health condition, with no chronic systemic disease or smoking habits. Patients were excluded if any of the following were evident: bruxism; unstable posterior occlusion and untreated caries; uncontrolled periodontal disease; adjacent teeth that exceeded Class I mobility; unrealistic expectations for the treatment; or inability or unwillingness to return for follow-up visits. All patients provided informed consent to participate in this study, and treatments were performed in accordance with the Helsinki Declaration.

Teeth

In the selected patients, teeth indicated for removal had to demonstrate at least 5 mm of bone beyond the root apex and at least 12 mm height and 5.5 mm width of available bone. Teeth with no-manageable recessions and/or without labial or lingual plate, as described in

1993 by Gelb,¹⁴ or teeth with active periapical lesions or active periodontal lesions, were excluded. Indications for tooth extraction and immediate implant placement included a history of trauma, root fractures, endodontic failure, and nonrestorable crowns. Radiolucency at the apex, without signs of activity (pain, fistula, redness, and suppuration) was included in the indications. Oral examination focused on the "smile line," intra-arch relationship, buccolingual width, and maxilla-mandibular relationship was assessed. Tomograms and periapical radiographs were evaluated for mesio-distal width, residual bone beyond the apex, socket width, and root angulation.

Surgical Procedure

BioLok SilhouetteTM (now marketed by BioHorizons, Birmingham, AL, USA) implants were placed using the surgical procedure that was advocated by the manufacturer. One gram of amoxicillin was administered 1 hour prior to surgery. Chlorhexidine rinses were used prior the surgery, and amoxicillin (500 mg three times daily) were continued for 5 to 7 days postsurgery. After local anesthesia, no flaps were designed and no incisions were made. Teeth were carefully removed and the sockets debrided. The distance between the gingival margin and 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 (mean 12.9 mm, range 11.5–15 mm) and widest (mean 4.4, range 4.0–5.0 mm) possible implants were placed. The implant was inserted at the most coronal part of the alveolar crest, and special attention was paid to a three-dimensional positioning of the implant as described by Buser and colleagues.¹⁵ Final implant position was carried out utilizing a torque driver (Torque-Controller, Nobel-Biocare, Gothenburg, Sweden). An acrylic resin splint that had been made preoperatively was fused to the impression coping after implant placement. The distance between the coronal part of implant and the gingival margin was used to choose the cover screw height. In all the sites there was no need for suturing. A temporary resin crown was made on the temporary abutment, and it was connected to the implant within 2 weeks after implant placement. Special care was taken to prevent any centric and eccentric contacts on the provisional crowns. Regular controls were performed every 2 weeks with special attention to occlusion and hygiene. After 6 months, when soft tissue

conditions were expected to have stabilized, the provisional abutments were substituted with zirconia abutments, and the provisional crowns were substituted with all-ceramic crowns. Implant stability was measured and confirmed by Perio-test (Siemens AG, Bensheim, Germany). Evaluations were made at baseline ([BSL], i.e. provisional restoration placement), at definitive crowns delivery, and each subsequent year after BSL. A periapical radiograph using the long-cone paralleling technique was taken at BSL and after each year. Each X-ray holder (XCP Bite Block®, Dentsply Rinn, Elgin, IL, USA) had been individualized with an occlusal jig (Futar D Fast®, Kettenbach Dental, Eschenburg, Germany) in order to standardize the procedure. The radiographs were then digitalized using a dedicated scanner (HP 3000; Hewlett-Packard Development Company, Palo Alto, CA, USA) with a resolution of 2,048 × 3,072 lines and converted into JPG files. A software package (AutoCAD 2000, Autodesk, Inc., San Rafael, CA, USA) was used to measure changes in marginal bone levels at the mesial and distal aspects of the implants (SprintScan 35 Plus®, Polaroid, Cambridge, MA, USA) and by using the appropriate software (Vixwin 2000 v1.11®, Dentsply Gendex, Lake Zurich, Switzerland).

The following clinical variables were recorded:

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

Soft tissue dimensions were measured as follows:

1. Papilla levels. The levels were recorded by means of an acrylic stent provided with direction grooves. Papilla level (mesial and distal) was defined as the distance from the top of the groove to the top of the papilla measured to the nearest 0.5 mm using a manual probe (CP 15 UNC, Hu-Friedy®).
2. Midfacial mucosa level. The level of the peri-implant mucosa at the midfacial aspect of the

tooth/restoration was measured using the same acrylic stent provided with a central direction groove. The midfacial level was defined as the distance from the top of the groove to the first contact with the peri-implant mucosa measured to the nearest 0.5 mm using a manual probe (CP 15 UNC, Hu-Friedy®). The Pink Esthetic Score (PES) proposed by Fürhauser and colleagues¹⁶ was used to evaluate the aesthetic outcome of the peri-implant soft tissues. This index includes seven variables: mesial papilla, distal papilla, midfacial level, midfacial contour, alveolar process deficiency, soft tissue color, and soft tissue texture. Each parameter is assessed with a 0-1-2 score with 2 being the best and 0 being the worst score.

The White Esthetic Score (WES) proposed by Belser and colleagues¹⁷ was used to evaluate the aesthetic outcome of the visible part of the implant restoration. This index includes five variables: tooth form, tooth volume, tooth color including the assessment of hue and value, tooth texture, and translucency. Again, each parameter is assessed with a 0-1-2 score with 2 being the best and 0 being the worst score. Thus, a maximum score of 10 can be reached. All variables are assessed by comparison with a reference tooth, which is the contralateral tooth for incisor and cuspid replacements. As proposed by Cosyn and colleagues,¹³ a score of 6/10 was considered acceptable, and a score of 9/10 or more was considered (almost) perfect. The overall aesthetic outcome was assessed by combining the results of the PES and WES. If PES ≥ 12 and WES ≥ 9, the treatment was considered (almost) perfect. If PES < 8 and/or WES < 6, the result was considered a failure.

Statistical Analysis

Data analysis was performed using the patient as the experimental unit. For all parameters, mean values were calculated, if applicable. Descriptive statistics also included frequency distributions for papillae and midfacial mucosa level. The changes between the BSL and 5-year reassessment were examined using the Wilcoxon signed ranks test. The level of significance was set at 0.01.

RESULTS

Implant Survival and Complications

Table 1 summarizes the clinical data of patients and implants included in this study. One implant was lost at

TABLE 1 Overview of Clinical Data of Patients and Implants Included in This Study

Tooth	Reason	Implant Diameter/ Length (mm)	Torque	Perio-Test Value*	Bone Quality†
Central incisor	ENDO	4.5 × 13	35 Ncm	+1	3
Lateral incisor	FRACTURE	4.0 × 13	40 Ncm	0	2
Canine	NRC	4.0 × 13	35 Ncm	0	3
Central incisor	ENDO	4.5 × 15	45 Ncm	+1	2
Central incisor	NRC	4.5 × 11.5	35 Ncm	+1	3
Lateral incisor	FRACTURE	4.0 × 11.5	32 Ncm	0	3
Lateral incisor	ENDO	4.5 × 13	35 Ncm	0	2
Canine	ENDO	5.0 × 15	45 Ncm	1	2
Central incisor	NRC	4.5 × 13	40 Ncm	0	2
Central incisor	FRACTURE	4.5 × 11.5	35 Ncm	−1	3
Central incisor	ENDO	4.5 × 13	35 Ncm	−1	3
Lateral incisor	FRACTURE	4.5 × 13	40 Ncm	0	2
Canine	NRC	4.0 × 13	35 Ncm	0	3
Central incisor	ENDO	5.0 × 15	45 Ncm	+1	2
Central incisor	NRC	4.5 × 11.5	35 Ncm	−1	3
Lateral incisor	FRACTURE	4.0 × 11.5	32 Ncm	−2	3
Lateral incisor	ENDO	4.5 × 13	35 Ncm	−1	2
Canine	ENDO	5.0 × 15	45 Ncm	0	2
Central incisor	NRC	4.5 × 13	40 Ncm	+1	2
Central incisor	FRACTURE	4.5 × 11.5	35 Ncm	0	3

*Perio-test value 6 months postinsertion.

†According to Lekholm and Zarb.⁵⁵

ENDO = endodontic failure; NRC = non-restorable crown.

6 months follow-up observation period (tooth location 13; diameter 5 mm – length 14 mm) and not included in the final study group. Besides this one early failure, all implants remained well integrated resulting in a 95.2% implant survival rate after 5 years of function. With respect to complications, one permanent crown lost retention at 24 months of follow-up and was re cemented. There were no other technical, nor biologic complications.

Hard Tissue Parameters. Table 2 shows mean bone loss from BSL (provisional crown placement) and 5-year

reassessment. Bone loss significantly increased between these intervals ($p < .01$). At the baseline, the average distance from the implant reference point to the marginal bone level was 0.12 mm mesial and 0.10 mm distal, respectively, with a mean overall distance of 0.11 mm. The corresponding mean distance at the definitive crown placement 6 months later was 0.51 mm (0.55 mm mesial and 0.47 mm distal), and at the end of examination period was 0.94 mm (0.98 mm mesial and 0.90 mm distal). Subsequently, the mean coronal bone level change was 0.40 mm at 6 months and 0.83 mm at 5 years (Figure 1, A–C).

TABLE 2 Marginal Bone Loss in Relation to BSL, at DCD (6 Months) and at 5 Years

Location	BSL	DCD	5 Years	p Value
Mesial bone loss (mm)	0.12 (0.05) [0.00–0.68]	0.55 (0.26) [0.10–0.97]	0.98 (0.50) [0.17–1.85]	<0.01
Distal bone loss (mm)	0.10 (0.04) [0.02–0.41]	0.47 (0.24) [0.08–0.85]	0.90 (0.68) [0.32–2.00]	<0.01

Mean, (SD) [range].

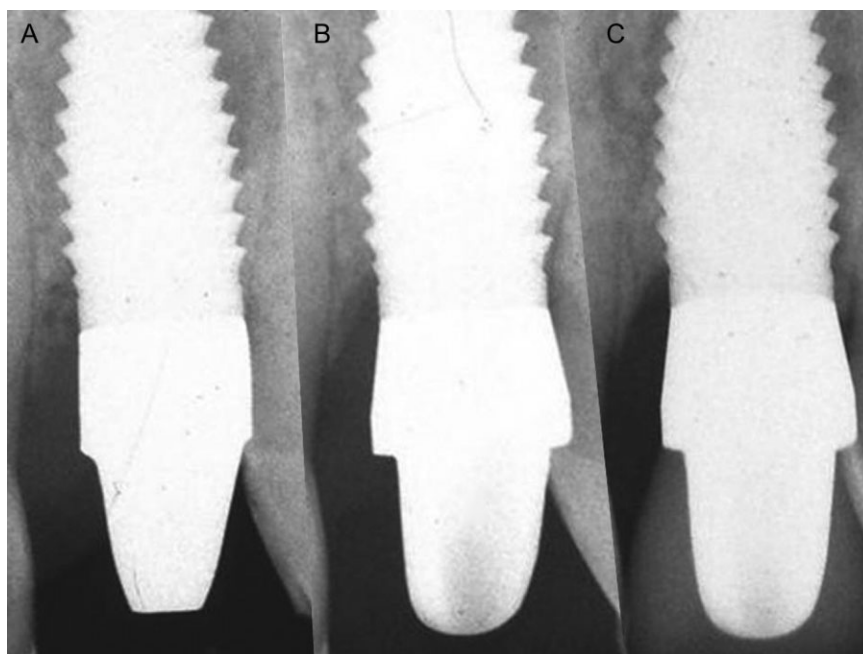


Figure 1 Example of radiographs taken after connection of provisional abutment (A), after connection of zirconia abutment 6 months later (B), and after 5 years (C).

Soft Tissue Parameters. In Table 3, the clinical conditions of the implant restorations are shown. Throughout the study period, mean plaque levels remained low (<15%) indicating good oral hygiene. Between baseline and 5 years, a significant reduction in probing depth from 2.52 mm to 2.14 mm occurred coinciding with a significant bleeding on probing drop from 40% to 21%.

In Table 4, dimensional changes of the soft tissue outline around the implant restorations in relation to the status prior to tooth extraction are reported. Mesial papillae showed a significant regrowth between 1 and 5 years pointing to a mean regrowth of 2.6 mm from the preoperative status at study termination. A similar trend was found for distal papillae, resulting in a final regrowth of 2.5 mm. At 5 years follow-up, mesial papilla loss (>1 mm) was found in 1/20 (5%) and distal papilla loss (>1 mm) in 1/20 (5%) cases. In 16/20 (80%)

patients mesial papillae, and in 15/20 (75%) patients distal papillae, regained respectively at least their original height (Figure 2, A–C).

The midfacial mucosa level did not alter significantly between the BSL and 5-year reassessment. At study termination a mean recession from the preoperative status of 0.10 mm was found (Table 4). At 5 years follow-up, midfacial recession (>1 mm) was found in 1/20 (5%) cases. In 13/20 (65%) patients, the midfacial mucosa regained at least its original level (Figure 3, A–C).

In Table 5, detailed values of PES and WES of all the 20 implants are shown. Table 6 summarizes results of all criteria of the PES and of the WES. Mesial papilla level and soft tissue color and texture were most satisfying showing a perfect match with the corresponding tooth in 16/20 (80%) and 17/20 (85%) cases, respectively.

TABLE 3 Clinical Conditions at BSL, DCD (6 Months), and at 5 Years

Location	BSL	DCD	5 Years	<i>p</i> Value
Plaque score (%)	12 (8) [0–30]	10 (7) [0–26]	10 (8) [0–28]	>0.01
Probing depth (mm)	2.52 (0.48) [1.80–3.22]	2.26 (0.53) [1.65–3.10]	2.14 (0.38) [1.52–3.00]	>0.01
Bleeding on probing (%)	40 (16) [0–75]	30 (12) [0–52]	21 (19) [0–50]	>0.01

Mean (SD) [range].

TABLE 4 Changes in Soft Tissue Dimensions in Relation to the Preoperative Status at BSL, DCD (6 Months), and at 5 Years

Location	BSL	DCD	5 Years	p Value
Mesial papilla (mm)	−0.24 (0.64) [−1.8/0.6]	−0.05 (0.7) [−1.2/1.5]	0.02 (0.58) [−0.4/1.8]	>0.01
Distal papilla (mm)	−0.21 (0.78) [−2/1.1]	−0.08 (1.20) [−1.65/2.0]	0.04 (0.83) [−1.2/2.0]	>0.01
Midfacial mucosa level (mm)	−0.23 (0.66) [−1.7/0.5]	−0.24 (0.70) [−1.8/1.0]	−0.10 (0.61) [−1.2/1.1]	>0.01

Mean (SD) [range]; negative value indicates recession in relation to the preoperative status.

Unfavorable results were most prevalent for the alveolar process showing severe deficiency in 3/20 (15%) cases. Two out of 20 (10%) cases showed an acceptable outcome and 15/20 (75%) an (almost) perfect result (Figure 4, A-C). Tooth and color and translucency were most satisfying indicating an ideal result in 17/20 (85%) cases. Unfavorable results were most prevalent for tooth texture and tooth volume with a mismatch in 5/20 (25%) and a perfect result in 15/20 (75%) cases.

The overall aesthetic outcome was assessed by combining the results of the PES and WES. Seven out of 20

(35%) single implant treatments showed a (almost) perfect result (PES ≥ 12 and WES ≥ 9). An acceptable result (PES: 8–11 and WES: 6–8) was found for 13/20 (65%) cases. The aesthetic outcome was unfavorable for 0/20 (0%) single implant treatments.

DISCUSSION

In the present study, 95.2% of the implants survived after 5 years of function. These data correspond well with the existing knowledge on survival rate of implants replacing single-tooth in the anterior maxilla by means



Figure 2 Example of papilla regrowth found in 75% of treated patients. Clinical preoperatively situation (A), temporary crown (B), after 5 years (C).



Figure 3 Example of peri-implant mucosa level at the midfacial aspect found in 65% of treated patients. Clinical preoperatively situation (A), temporary crown (B), and after 5 years (C).

TABLE 5 Detailed PES and WES of the 20 Included Implants

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Patient	Implant Site	Mesial Papilla	Distal Papilla	Midfacial			Alveolar		Soft		Total PES	Tooth Form	Tooth Volume	Tooth Color	Tooth Texture	Translucency	Total WES	Total PES+WES
				Mucosa Level	Midfacial Contour	Process Deficiency	Tissue Color	Tissue Texture										
1	Central incisor	2	2	2	1	2	2	2	2	13	0	1	2	1	2	6	19	
2	Lateral incisor	1	1	2	2	2	2	2	2	12	2	2	1	0	2	7	19	
3	Canine	2	2	2	1	2	2	2	2	13	2	2	2	2	2	10	23	
4	Central incisor	2	2	2	2	2	2	2	2	14	2	2	2	2	0	8	22	
5	Central incisor	2	2	1	2	2	2	2	2	13	1	0	0	2	2	5	18	
6	Lateral incisor	1	1	1	0	0	1	0	0	4	2	2	2	2	2	10	14	
7	Lateral incisor	2	2	2	1	2	2	2	2	13	2	2	2	2	2	10	23	
8	Canine	2	2	2	2	2	2	2	2	14	1	1	1	0	1	4	18	
9	Central incisor	2	2	1	2	2	2	2	2	13	2	2	2	2	2	10	23	
10	Central incisor	0	0	0	1	1	0	0	2	4	2	2	2	2	2	10	14	
11	Central incisor	2	2	2	2	2	2	2	2	14	1	1	0	1	2	7	21	
12	Canine	1	1	1	0	0	1	1	1	5	2	2	2	2	2	10	15	
13	Central incisor	2	2	2	1	2	2	2	2	13	2	2	2	2	1	9	22	
14	Central incisor	2	2	2	2	2	2	2	2	14	2	2	2	2	2	10	24	
15	Central incisor	2	2	2	2	2	2	2	2	14	2	1	2	1	2	8	22	
16	Lateral incisor	2	1	1	2	0	2	2	2	10	2	2	2	2	2	10	20	
17	Lateral incisor	2	2	2	2	2	2	2	2	14	2	2	2	2	2	10	24	
18	Canine	2	2	2	2	2	2	2	2	14	2	2	2	2	2	10	24	
19	Central incisor	2	2	2	2	1	2	1	1	12	2	2	2	2	2	10	22	
20	Central incisor	2	2	2	2	2	2	2	2	14	2	2	2	2	2	10	24	

TABLE 6 Summarized PES and WES of the 20 Included Implants

	Value 0	Value 1	Value 2
Parameter PES			
Mesial papilla	1	3	16
Distal papilla	1	4	15
Midfacial mucosa level	1	3	16
Midfacial contour	2	5	13
Alveolar process deficiency	3	2	15
Soft tissue color	1	2	17
Soft tissue texture	1	2	17
Parameter WES			
Tooth form	1	3	16
Tooth volume	1	4	15
Tooth color	1	2	17
Tooth texture	2	3	15
Translucency	1	2	17

of immediate implantation and immediate provisionalization reported in literature.¹¹ Most of published studies show in the short term an implant survival rate of 100%, whereas in longer observation period, survival rate varies between 78.6% to 100%. Wohrle¹⁸ in observation period ranging from 9 to 36 months reported 100% of survival rate, whereas Ferrara and colleagues¹⁹ in 12 to 50 months follow-up period, and Groisman and colleagues²⁰ in 24 months follow-up period, showed 93.9% and 93.5% of survival rate, respectively. The lower survival rate of 78.6% for immediate implantation and provisionalization in anterior maxilla is reported by Chaushu and colleagues⁹; however, their results may be connected by the use of press-fit implants and by the fact that all the failed implants were placed in premolar

area where the probability of increased lateral load is greater. A survival rate of 95.2% at 5 years found in the present study confirms data published showing that the timing of implant placement and loading relative to single-tooth extraction does not seem to be decisive for implant survival, as success rate is at least comparable with data published for single-tooth implants placed according to the standard protocol in healed sites.¹² Implant survival rate has been always considered the main criterion for success of any implant-supported restoration procedure, but in the last years implant dentistry is strongly evolved and to optimize esthetics and to preserve hard and soft peri-implant tissues is now mandatory. Today, the level of peri-implant marginal bone loss is considered a determining factor in evaluation of the quality of survival (and thus of primary outcome). Because peri-implant bone loss may induce pocket formation, which could be unfavorable for the long-term health of the peri-implant tissues,²¹ peri-implant marginal bone loss can also be considered as an index to determine the aesthetic outcome. Measurements of marginal bone on periapical radiographs is generally accepted as a reliable instrument to measure the bone level at the proximal side of the implant from the moment of placement to years thereafter. Results of present study indicate a mean peri-implant bone loss of 0.94 mm at 5 years follow-up, and these values are consistent with what has been reported in literature on single-tooth implants in the anterior zone placed in according with the original protocol.^{12,22} Hence, the results of present study seem to confirm the hypothesis that immediate implantation and early provisionalization is at least as favorable as the standard protocol in preserving hard tissues. Data reported by others studies



Figure 4 Example of buccal convexity and tissue contour found in 75% of treated patients. Radiograph (A) and clinical situation (B,C) at 5 years follow-up control.

on immediately placed and provisionally restored single-tooth maxillary implants indicate a mean peri-implant bone loss between 0.2 mm and 0.5 mm at 1 year follow-up,^{23–25} with ongoing loss thereafter reaching an average 0.75 mm crestal bone loss at 2 years follow-up.²⁶ These data seem to suggest, at least in the short term, a lower bone loss as compared with published data on conventionally placed and loaded implants showing peri-implant bone loss of about 1 mm during the first year.^{27–30} However, it should be pointed out that between reported data, there is variety in the peri-implant bone level evaluation over time, because studies used different starting points for their analysis. In the various studies, the first radiographic examinations had been performed just after implant placement, after healing abutment connection, at temporary crown placement, or at definitive crown delivery. Because of this heterogeneity, it is not possible to draw conclusions concerning differences in marginal bone changes between the several treatment strategies. Therefore, more long-term prospective and controlled clinical studies are mandatory to confirm the hypothesis of lower marginal bone implant loss when using immediate implantation and immediate/early provisionalization strategy.

It is known that the proximal bone level next to the adjacent teeth is highly relevant for the level of the proximal papillae of the implant.³¹ Providing that this bone peak is preserved during atraumatic extraction of the hopeless tooth and implant placement, the proximal papilla can be secured.^{15,31,32} In the present study, mesial and distal papillae showed a significant regrowth between 1 and 5 years, pointing mesial papillae to a mean regrowth of 2.6 mm and distal papillae to a mean regrowth of 2.5 mm. At the 5-year reassessment, papillae had basically regained their original height. These data are in agreement with previously published data on immediately placed and provisionally restored single-tooth maxillary implants²⁵ and indicate that the presence of papillae may not be the key issue following immediate single implant treatment providing these were intact at the time of tooth loss. Similar observations on papilla stability have been also described following conventional implant surgery.^{30,31} In these studies, the bone peak at the adjacent tooth was considered the pivotal factor in maintaining papilla height between a single implant and tooth and at least when comparing early to delayed placement of single-tooth implants, it has been shown that

there is no difference in papilla height after 1.5 years of follow-up.³³

Currently available data indicate that immediate implant placement does not prevent resorption of the ridges. Several studies^{34–38} have shown that the resorption of the buccal and lingual walls at 3 months is similar compared with extraction only sites. Accordingly, it has been suggested that implants placed in extraction sockets are not able to prevent soft tissue loss, especially the buccal marginal tissue recession. However, the amount of soft tissue alterations seems to be determined by many factors. Chen and colleagues^{39,40} demonstrated a significant relationship between the frequency of recession and the buccolingual position of the implants. This concept has also been confirmed with reentry surgery at 4 months in a randomized controlled clinical trial of implants installed immediately into extraction sockets.⁴¹ Furthermore, recession of >5% was more prevalent at sites with thin periodontal biotypes than at those with a thick biotype. To reduce the risk for soft tissue recession, a number of prerequisites have been described,¹¹ and when immediate implant placement is indicated, careful presurgical examination of future implant sites and placement of implants in the prosthetically correct position should be carried out to achieve and maintain satisfactory aesthetic outcomes. The midfacial mucosa level following single implant treatment is an issue that gained a lot of attention in recent studies.^{39,42–45} Data present in literature on midfacial mucosa level following single implant treatment are however contrasting: Chen and Buser⁴⁶ report an increased risk for advanced midfacial recession >1 mm, whereas other authors^{25,47} reported a limited risk, with midfacial gingival recession between 0.55 mm and 0.75 mm. In the present report, the midfacial mucosa level did not alter significantly between the BSL and 5-year reassessment. Only 1/20 (5%) of our cases demonstrated more than 1 mm recession after 5 years, and in 13/20 (65%) patients, the midfacial mucosa regained at least its original level. Our findings contrast the conclusion of article by Chen and Buser,⁴⁶ yet seem to be in agreement with other clinical studies describing a low risk for advanced midfacial recession following immediate single implant treatment.^{13,44,48–50} As suggested by De Rouck and colleagues,⁵⁰ it seems that immediate stabilization of the soft tissue after tooth removal by means of immediate implant placement and immediate placement of

temporary crown revealed more soft tissue preservation midfacially compared with delayed strategy. The contradiction about the risk for advanced midfacial recession present in literature may be however explained by disparities in study design (prospective vs retrospective), recording procedure (using a stent or standardized digital slides with fixed reference points or not), case selection (buccal bone crest intact or not, presence or absence of no-manageable recessions), surgical aspects (surgeon's experience; implant type), and restorative aspects (immediate/early provisionalization or not). Results of the present study, revealing a low risk for advanced midfacial recession (1/20 [5%] cases), may be also related to strictly selection criteria of inclusion we have used. In all selected patients, extraction sites had to demonstrate hard and soft tissue preservation. Moreover, the most frequent reasons of extraction in present study were endodontic failures and nonrestorable crown, which could not lead to severe marginal bone loss. We realize that samples size of our study is too small to demonstrate whether immediate implant placement with early placement of the temporary crown may allow the preservation of the midfacial soft tissue; however, from our experience, the final result seems be strongly related to the starting point: when the starting point is favorable, favorable aesthetics could be expected from an implant-based single-tooth replacement, whereas an unfavorable starting point might lead to unsatisfactory results. Given the complexity of this aspect of treatment outcome, a thorough systematic review would be valuable specifically comparing the risk for advanced midfacial recession between immediate/early and conventional single implant treatment.

Few case series have been published documenting the aesthetic characteristics of single implants crowns using objective parameters.^{17,45,51} Most of these studies reported that optimal esthetics seems difficult to achieve in spite of the fact that patients had been selected on the basis of stringent criteria and treated by experienced clinicians. These data are in agreement with our results, showing 15% of the cases have less favorable results on these aspects. It imposes an important reflection on implant therapy outcomes because esthetics is more and more becoming the key for success in daily practice, and today the concept of immediate implantation and immediate/early provisionalization for replacing single teeth in anterior

maxilla seems appealing for the clinician and for the patients especially to satisfy the aesthetic requirements. If maxillary anterior single-tooth implant therapy is selected, the patient must be informed about the esthetic risk associated with the implant treatment. Careful case selection, appropriate surgical and restorative procedures, appropriate implant design and surface, and clinical experience are considered of pivotal importance. Regarding the immediate/early loading of single-tooth implants placed in fresh extraction sockets is suggested immediate/early provisionalization only in case of optimal primary stability (>32 Ncm).^{11,18,24} According with these data, all the implants of present study were inserted with a final torque >32 Ncm, and the median Perio-test values recorded 6 months after insertion were in the ranges of implants placed using standard protocols (minimum of -1 and a maximum of $+2$). A space greater than 1.5 mm does not allow for proper bone integration of dental implants at the coronal aspect of the fixture if no membrane is used.⁵² In present study, all the selected extraction sites were characterized by favorable anatomic condition, and in all the patients, we used tapered implants with 4, 4.5, or 5 mm diameters. In which way the space between socket bone walls and the coronal aspect of the fixture always was reduced to 0.5 to 1 mm. Implants surface represent another important factor in achieving success rate using immediate implantation and provisionalization protocol. Implants with a rougher surface may be better suited than machined-surface implants for use under early functional forces.⁵³ In the present study, we used tapered implants with sandblasted and acid-etched microsurface and with reverse buttress threads which, in a vitro study,⁵⁴ have been demonstrated to be more effective in resisting loading compared with the "V" thread. Moreover, also the surgical flapless technique might represent another important factor in achieving success as vascular ischemia associated with periosteal reflection has been implicated as a potential source of cortical bone loss. In addition, we have pursued the concept of immediate nonocclusal loading, and provisional restorations were cleared of all contact in centric occlusion to avoid full functional loading of the implant during healing. The advantages of immediate implant placement and provisionalization technique are obvious and include immediate function and esthetic; however, when considering this kind of strategy, clinician should

be reserved and should take into consideration all the necessary over mentioned prerequisites.

This study has limitations due to the number of observers and implants. Therefore, more prospective studies monitoring soft tissue dynamics over longer time periods and encompassing a larger number of observers and a larger number of implants are needed. However, within the limits of the present study, we can say that our results show that early restoration of single-tooth implants placed in fresh extraction sockets with hard and soft tissue preservation, may be considered a predictable procedure in terms of implant survival and hard and soft tissue remodeling.

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