Nonremoval of Immediate Abutments in Cases Involving Subcrestally Placed Postextractive Tapered Single Implants: A Randomized Controlled Clinical Study

Marco Degidi, MD, DDS;* Diego Nardi, DDS;† Giuseppe Daprile, DDS;† Adriano Piattelli, MD, DDS‡

ABSTRACT

Purpose: The aim of this trial was to assess if the nonremoval of abutments placed at the time of surgery would improve bone and gingival healing around single immediately restored implants placed in postextraction sockets.

Materials and Methods: All patients received a single square-threaded tapered implant placed in postextraction sockets and immediately restored. All the implants were placed 2.0 mm below the bone crest, avoiding any contact with the coronal portion of the buccal wall. Six months after surgery, 35 patients were treated following the control standard prosthetic protocol: the abutments were removed and impressions were made directly on the implant platform. Thirty-three patients underwent the "one abutment at one time" test protocol: impressions were made of the abutments using snap-on abutment copies. The dimensional changes of the soft and hard tissues were assessed using digital photography and cone beam computed tomography radiographs immediately after surgery and at 6-, 12-, and 24-month follow-up examinations.

Results: All implants were osseointegrated and clinically stable at the follow-up examinations. No statistically significant difference was evidenced between the two groups regarding the measurement of vertical bone healing. After the placement of the final restoration, a significant horizontal loss in the hard tissue portion over the implant platform was assessed ($p = .03$ mesial sites; $p = .04$ distal sites). An 87% increase of the mean recession of the buccal soft tissue was observed in the control group (+0.27 mm) in the same time frame.

Conclusions: The nonremoval of abutments placed at the time of the surgery improves the stability of healed soft and hard tissues around the immediately restored, subcrestally placed tapered single maxillary implant.

KEY WORDS: alveolar bone remodeling, CBCT imaging, chamber concept, immediate loading

INTRODUCTION

The concept of placing an implant into a fresh extraction site has been evaluated many times[1] since it was first discussed in the literature.[2] The first guidelines were that, once the compromised tooth had been extracted, the alveolar socket was more or less to be completely obliterated by the immediately placed implant. These implants used to be placed precisely in the middle of the socket, at an equicrestal depth, in order to provide support for the bone walls of the socket itself. Recently, this approach has been revised: implants placed closer to the palatal wall are used and reduced diameter implants have been advocated,[3] with the intention of reducing the predicted bone loss on the buccal side as much as possible. The depth of the placement has also changed. Originally, the increase of the sinking depth of the collar of standard two-piece butt-joint connection implants was supposed to compensate for the loss of vertical bone height,[4] but some authors demonstrated that this implant design results in an increased bone loss if placed beneath the bone crest.[4,5] The introduction of tapered implants with a moderately rough surface and a shifted

*Private practice, Bologna, Italy; †private practice, Bologna, Italy; ‡Full professor, Department of Medical, Oral, and Biotechnological Sciences, University of Chieti-Pescara, Chieti, Italy

Reprint requests: Prof. Adriano Piattelli, Via F. Sciucchi 63, 66100 Chieti, Italy; e-mail: apiattelli@unich.it

DOI 10.1111/cid.12051

platform design enabled surgeons to place the implant at a deep subcrestal depth. With the use of this approach, the neck of the abutment is placed in a three-dimensional space that has an excellent blood supply and that is rich in healing and osteogenic factors that are created as a consequence of surgery. In a recently published paper,[6] the authors studied the effects of abutment removal on bone healing after the subcrestal placement of immediately restored tapered implants placed in healed sites and observed a statistically significant reduction of horizontal bone dimensional change. The objective of this study was to assess if the nonremoval of abutments placed at the time of the surgery would improve bone and gingival healing around single implants placed in postextraction sockets and immediately restored.

MATERIALS AND METHODS

Study Population

This study was designed as randomized controlled trial conducted in accordance with the latest revision of the World Medical Association Declaration of Helsinki following the "As low as reasonably achievable" (ALARA) principles.[7] The study included patients with an age of 18 years or more with a single compromised tooth in the canine to canine maxillary anterior sector. The characteristics of the opposing dentition were not considered to be a discriminating factor. All patients were consecutively included and signed a specific written informed consent form. Each of them received a single 3.5 or 4.5 mm–diameter square-threaded, grit-blasted, and acid-etched implant with a tapered connection (ANKYLOS®, DENTSPLY Friadent, Mannheim, Germany) positioned in a fresh extraction socket. Patients were not accepted into the study if they met any of the following exclusion criteria: (1) active infection in the sites intended for implant placement; (2) systemic disease that could compromise osseointegration; (3) treatment with radiation therapy in the craniofacial region within the previous 12 months; (4) if they smoked more than 10 cigarettes per day; (5) pregnancy or lactation; (6) bruxism; and (7) unsuitable quantity of bone in the surgery site or need of bone augmentation procedures prior to implant placement. All implants were placed in postextraction sockets by one experienced surgeon (M.D.) in a private dental office in Bologna, Italy.

Surgical Intervention

Preoperative analysis of the surgical site was performed using a periapical radiograph. Impressions were made of the maxilla and mandible, and laboratory casts were made. The shade and mold of the prosthetic tooth were selected and an appropriate all-composite commercial tooth (Visio.lign, Bredent GmbH, Senden, Germany) was chosen and hollowed out. Antimicrobial prophylaxis was obtained with the use of 500 mg of beta-lactam antibiotics (Amoxicillin, Pfizer Manufacturing, Puurs, Belgium) twice daily for 5 days, starting 1 hour before surgery. Before surgery, the gingival biotype of patient was classified as thin or thick,[8] depending on the positive or negative visibility of an underlying periodontal probe through the gingival tissue.[9] Local anesthesia (2% articaine/adrenaline 1:100,000) was administered at the time of surgery. Surgery began with the careful extraction of the compromised tooth. Extreme attention was kept in order to preserve the integrity of all the walls of the socket. The surgery was performed using a flapless protocol. A single 14- or 17.0-mm-long implant was placed with the rough crestal collar positioned at least 2.0 mm beneath the bone crest. During the placement procedure, the insertion torque and the implant stability quotient (ISQ) were recorded by a surgical handpiece (FRIOS Unit E, W&H Dentalwerk GmbH, Buermoos, Austria) and a digital measurement probe (Osstell AB, Gamlestadsvägen 3B, Göteborg, Sweden). Patients were dropped from the study if one of the following clinical exclusion criteria were met: (1) implant insertion torque <25 Ncm; (2) an ISQ < 60; and (3) any kind of loss of integrity observed in the socket walls, such as dehiscence, fenestration, or fracture caused by implant insertion.

Prosthetic Intervention

If patients had none of these exclusion criteria, the standard prosthetic abutment (Standard A®, DENTSPLY Friadent, Mannheim, Germany) was connected to the implants of each individual patient; a gold coping was then placed on the standard abutment and cut to the proper length according to the dimensions of the temporary crown. The coping was sandblasted and opaqued, and the temporary composite crown was relined over the coping with a small quantity of dual cure composite. The crown was removed from the oral cavity with the embedded coping, further filled with composite, trimmed, polished, and reinserted. Correct vertical dimension and occlusion were checked in order

to avoid centric and lateral excursion contact. The crown was engaged with the abutment using conic coupling and secured with a lingual screw. No sutures were employed. Oral hygiene instructions were provided and patients were instructed to have a soft diet for 8 weeks. Twenty-four weeks after implant insertion, the provisional crown was removed, implant mobility was checked, and final impressions were taken using polyether impression material (Impregum, 3M-Espe, St. Paul, MN, USA). All cases were randomly assigned to one of the two procedures tested following a locked list created with a nonrepeatable computerized random number generator (Quick Calc, GraphPad Software, Inc., Avenida de la Playa, La Jolla, CA, USA) before the impression phase.

Thirty-five patients were enrolled in a control group, which was subject the standard prosthetic protocol. The standard abutments were removed and the impressions were made directly on the implant platform with a customized tray using standard long pin components. Abutments were also removed three more times: at the metal framework and biscuit tryouts and at the time of the delivery of the final restoration, when they were substituted by new abutments.

Thirty-three patients were enrolled in the test group and underwent the *one abutment at one time* protocol.[6] Impressions were made on the abutments using a standard tray and a snap-on abutment copy.

During the manufacture of the final metal-ceramic restoration, the test group had the same number of tryouts as the control group, so that the only difference was the number of abutment removals. The final restorations were delivered approximately 6 months after implant insertion.

Clinical and Radiographic Evaluation

The following data set was recorded for each patient:

(1) Biological or technical complications or any other adverse event.
(2) Classification of the soft tissue biotype of the patient as thin or thick[8] by the means of the visibility of a periodontal probe under the midfacial gingiva of the failing tooth.[9]
(3) Soft tissue dimensional changes measured at the mesial, the buccal, and the distal sites using digital photographs as proposed by Kan and colleagues.[9,10] The baseline was set using a pretreatment photograph of the failing teeth. All the soft tissue measurements were performed by the same blind observer (G.D.) who was not involved in the surgery.
(4) Dimensional changes of the bone in the postextractive socket at the mesial, the buccal, the distal, and the palatal sites. Three measurements were taken for each site:
    (a) The vertical distance between the perpendicular projection of the peak point on the implant bevel plan and the top of the bone crest;
    (b) The horizontal distance between the implant surface and the inner wall of the socket at implant bevel level. This measurement had positive or negative values depending on the presence of a gap (positive) or implant platform bone overgrowth (negative);
    (c) The vertical distance between the implant bevel level and the first point of contact of the bone with the implant surface. This measurement assumed a zero value when implant platform bone overgrowth was present.

All the hard tissue measurements were performed by a second blind observer not involved in the surgery (D.N.) using cone beam computed tomography (CBCT; Kodak 9000 3D, Carestream Health, Rochester, NY, USA) radiographs taken at each follow-up. The observer was not involved in the surgery. The scans were done with the patients having their chins and heads stabilized using the following settings: dimension – 50×37 mm; voxel size – $76 \times 76 \times 76$ μm; gray scale –14 bits; and focal spot – 0.5 mm. The measurements were performed on the scans stored as anonymous CBCT Dicom data using dedicated manufacturer software (Kodak Dental Imaging Software, KDIS 6.12.21.0, Carestream Health, Rochester, NY, USA) and an already established protocol[11] (Figures 1–7).

The frequency of the follow-up was as follows:

(1) T0: after surgery and fitting of the immediate temporary restoration;
(2) T1: fitting of the final restoration, 6 months after surgery;
(3) T2: final restoration follow-up, 1 year after surgery;
(4) T3: final restoration follow-up, 2 years after surgery;

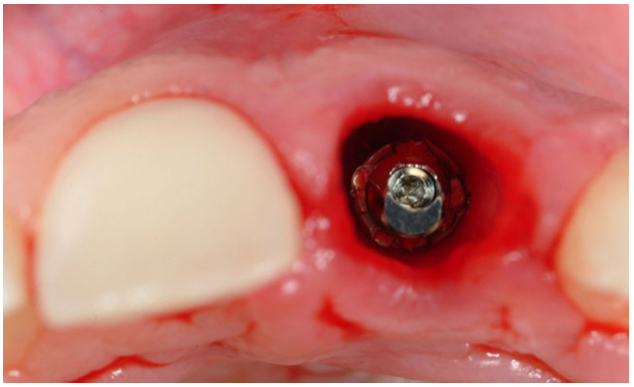

Figure 1 Occlusal view immediately after abutment connection (test group).

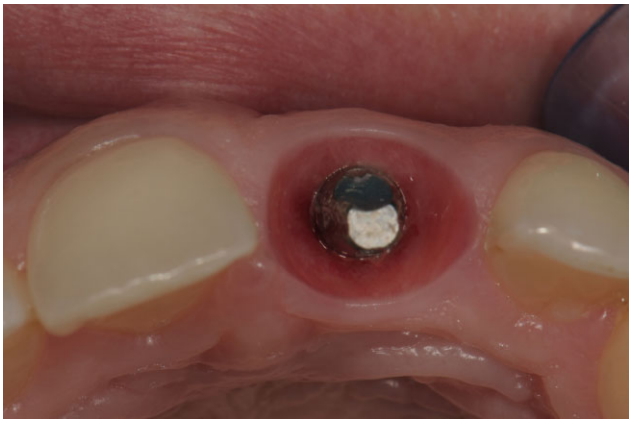

Figure 3 Occlusal view photographed at the placement of the final restoration (test group).

Intraobserver reliability checks were carried out for both the radiological and the photographic measurements in order to evaluate a possible method error. Ten patients were randomly selected using a nonrepeatable computerized random number generator (Quick Calc, GraphPad Software, Inc., Avenida de la Playa, La Jolla, CA, USA) and the complete data set of measurements was acquired again by the respective operator no later than 2 weeks after the first assessment.

Statistical Analysis

Statistically significant differences in the vertical and the horizontal bone levels between the test and the control group were assessed at each follow-up using the Mann-Whitney test with a 95% confidence interval ($p < .05$). Each patient received only one implant and each measurement site – mesial, distal, palatal, and buccal – was considered as a separated statistical element.

Reproducibility tests were performed using the Pearson's correlation coefficient.

RESULTS

A total of 91 patients that fulfilled the primary inclusion criteria were treated in the period between July 2009 and September 2010. Five cases were excluded because the postextraction socket was found to be unsuitable due to bone defects detected after the removal of the root. The patients were dropped from the study and underwent an augmentation procedure before a case reevaluation. Two implants failed to achieve the desired ISQ value and six failed to achieve the desired insertion torque. The cases were consequently dropped and treated using a provisional interim composite resin Maryland bridge and

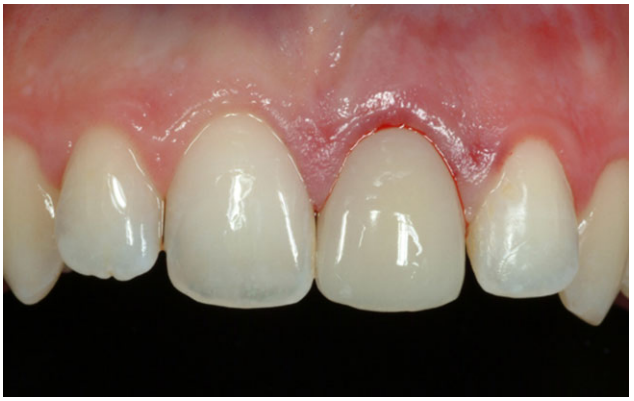

Figure 2 Frontal photograph of the temporary restoration taken immediately after the surgery (test group).

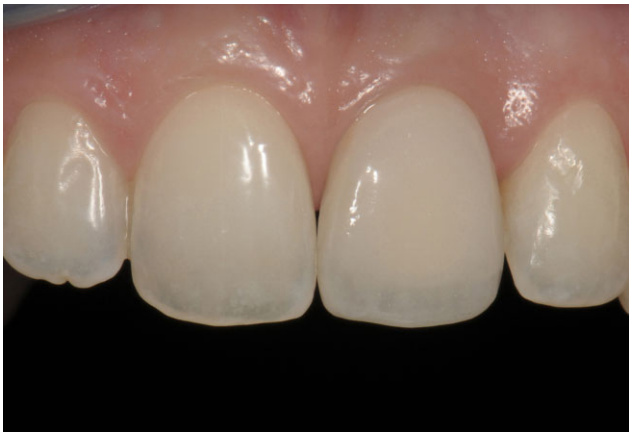

Figure 4 Frontal photograph of the final restoration taken at the 2-year follow-up (test group).

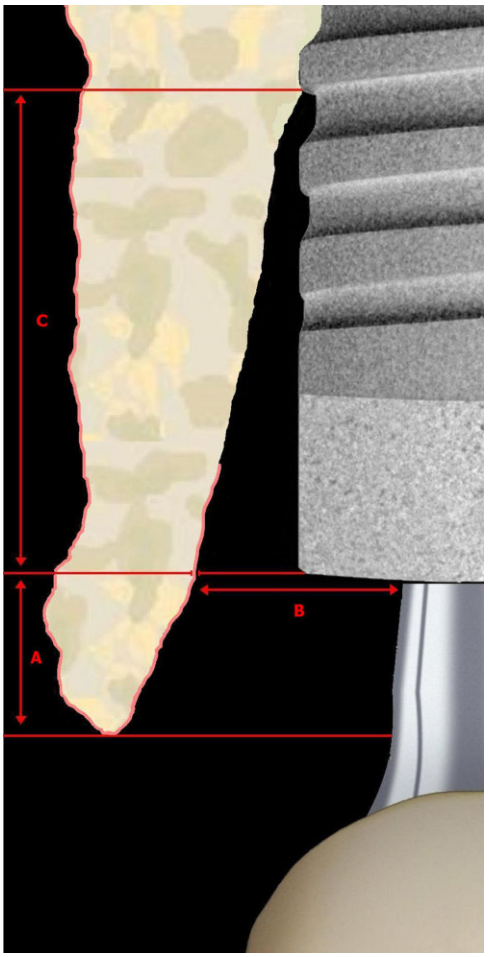

Figure 5 (A) Vertical distance between the perpendicular projection of the peak point on the implant bevel plan and the top of the bone crest. (B) Horizontal distance between the implant surface and the inner wall of the socket at implant bevel level. (C) Vertical distance between the implant bevel level and the first point of contact of the bone with the implant surface.

a delayed two-stage approach. Nineteen cases were excluded during the study because of poor CBCT imaging and scattering. Six cases were lost because they were unavailable for follow-up. A total of 24 implants of the test group and 29 implants of the control group reached the 2-year follow-up. The average insertion torque was 43.9 Ncm (SD 10.8, $n = 24$) for the test group and 45.1 Ncm (SD 12.3, $n = 29$) for the control group. The average ISQ value at surgery was 71.2 (SD 5.9, $n = 24$) for the test group and 71.9 (SD 5.3, $n = 29$) for the control group. The mean age of the patients that reached the 2-year follow-up was at the time of surgery 40.1 years (SD = 12.5; $n = 24$) for the test group and 37.7 years (SD = 14.3; $n = 29$) for the control group. The full measurement data set is summarized in Tables 1–6.

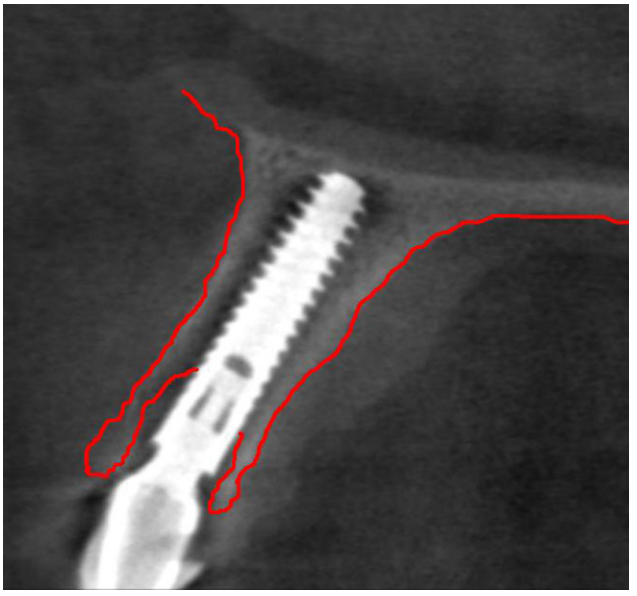

Figure 6 Cone beam computed tomography slide done after placement of the immediate temporary restoration.

No statistically significant difference was evidenced between the two groups regarding the measurement of vertical bone healing. After the placement of the final restoration, a significant horizontal loss in the hard tissue portion over the implant platform and an

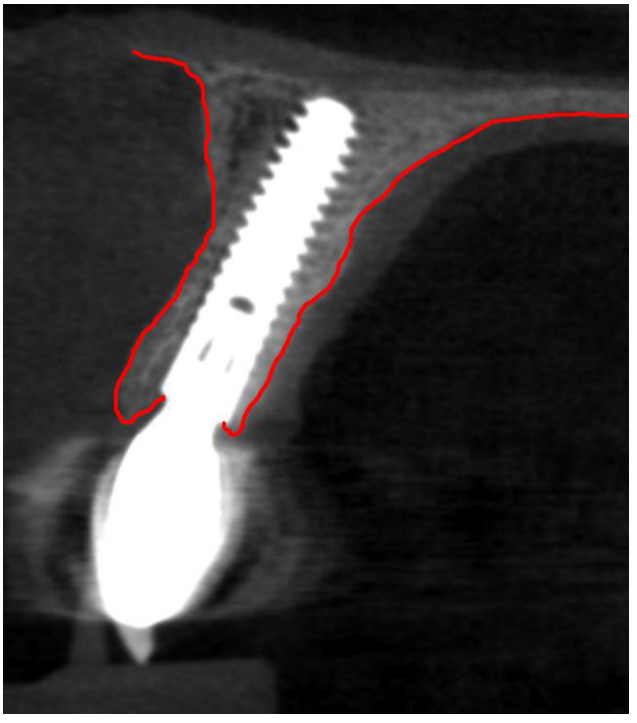

Figure 7 Cone beam computed tomography slide done at the 2-year follow-up.

TABLE 1 Buccal Site Measurements

	T0	T1	T2	T3
Horizontal distance between the implant surface and the inner wall of the socket				
Test group				
Mean	2.02	−0.22	−0.21	−0.18
SD	0.30	0.25	0.30	0.25
Min	1.59	−0.55	−0.67	−0.51
Max	0.29	0.24	0.29	0.17
Control group				
Mean	1.93	−0.22	−0.04	−0.03
SD	0.28	0.23	0.19	0.18
Min	1.53	−0.55	−0.37	−0.37
Max	2.48	0.20	0.31	0.39
p	0.29	0.94	0.03	0.02
Vertical distance between the implant bevel level and the first point of contact of the bone with the implant surface				
Test group				
Mean	4.07	0.18	0.15	0.17
SD	0.57	0.27	0.23	0.21
Min	2.86	0.00	0.00	0.00
Max	4.95	0.73	0.68	0.53
Control group				
Mean	3.77	0.17	0.21	0.18
SD	0.63	0.27	0.22	0.22
Min	2.77	0.00	0.00	0.00
Max	4.84	0.73	0.59	0.53
p	0.07	0.90	0.37	0.85
Vertical distance between the perpendicular projection of the peak point on the implant bevel plan and the top of the bone crest				
Test group				
Mean	2.21	1.42	1.29	1.25
SD	0.12	0.22	0.17	0.15
Min	2.02	1.02	1.05	1.03
Max	2.51	1.77	1.68	1.59
Control group				
Mean	2.15	1.38	1.24	1.18
SD	0.10	0.23	0.15	0.12
Min	2.02	0.97	0.98	0.97
Max	2.41	1.81	1.58	1.35
p	0.07	0.57	0.41	0.09

increased recession of soft tissue were found in the control group.

One patient of the test group reported moderate sensory disturbances in the labial mucosa associated with edema in the surgery site up to 3 weeks after surgery. The partial loss of thermal sensitivity in the mesial and distal teeth was also noted. The patient underwent a cycle of 40 mg of bromeline (Ananase, Rottapharm, Milano, Italy) three times a day for 1 week. The patient recovered full sensation after the resorption of the edema.

One patient was unsatisfied with the color shade of the provisional restoration. The temporary restoration was carefully removed and immediately replaced following the request of the patient.

One patient of the test group and two of the control group reported gum irritation immediately after the delivery of the final restoration. The three restorations were removed, carefully modified in order to reduce pressure on the soft tissue, and put into position the same day.

TABLE 2 Palatal Site Measurements

	T0	T1	T2	T3
Horizontal distance between the implant surface and the inner wall of the socket				
Test group				
Mean	0.51	−0.11	−0.15	−0.15
SD	0.27	0.43	0.23	0.18
Min	0.15	−0.69	−0.60	−0.54
Max	0.99	0.48	0.22	0.15
Control group				
Mean	0.53	−0.16	−0.08	−0.09
SD	0.26	0.25	0.19	0.18
Min	0.16	−0.60	−0.43	−0.48
Max	1.01	0.22	0.47	0.21
p	0.68	0.64	0.41	0.50
Vertical distance between the implant bevel level and the first point of contact of the bone with the implant surface				
Test group				
Mean	0.59	0.10	0.10	0.10
SD	0.27	0.13	0.18	0.19
Min	0.11	0.00	0.00	0.00
Max	1.09	0.40	0.65	0.51
Control group				
Mean	0.72	0.12	0.15	0.16
SD	0.39	0.15	0.20	0.20
Min	0.21	0.00	0.00	0.00
Max	1.78	0.43	0.66	0.59
p	0.32	0.89	0.71	0.30
Vertical distance between the perpendicular projection of the peak point on the implant bevel plan and the top of the bone crest				
Test group				
Mean	1.05	0.81	0.78	0.77
SD	0.14	0.16	0.12	0.09
Min	0.82	0.57	0.53	0.64
Max	1.37	1.19	1.01	0.94
Control group				
Mean	1.01	0.78	0.73	0.71
SD	0.15	0.14	0.12	0.09
Min	0.77	0.52	0.51	0.60
Max	1.25	1.06	0.97	0.99
p	0.43	0.61	0.20	0.04

The value of the Pearson's correlation coefficient used to assess intraobserver reliability was 0.895 for the radiological measurements and 0.911 for the photographic measurements.

DISCUSSION

This study radiologically analyzed dimensional changes of the postextraction sockets during the healing and the first 2 years of function of immediately placed tapered single implants. Two different prosthetic approaches were used to restore the implants, which were placed only in the canine to canine maxillary anterior sector. The study was designed as randomized and controlled, with concealed case allocation and measurements performed by trained operators not involved in the surgery. All radiological analyses were performed in accordance with the ALARA principles.[7] CBCT imaging is the only diagnostic method that can be used to tridimensionally

TABLE 3 Mesial Site Measurements

	T0	T1	T2	T3
Horizontal distance between the implant surface and the inner wall of the socket				
Test group				
Mean	1.03	−0.19	−0.20	−0.19
SD	0.45	0.41	0.26	0.22
Min	0.40	−0.75	−0.61	−0.54
Max	1.73	0.47	0.14	0.11
Control group				
Mean	1.09	−0.24	−0.05	−0.08
SD	0.42	0.33	0.19	0.17
Min	0.39	−0.69	−0.53	−0.45
Max	1.81	0.20	0.28	0.19
p	0.94	0.53	0.02	0.03
Vertical distance between the implant bevel level and the first point of contact of the bone with the implant surface				
Test group				
Mean	1.90	0.22	0.18	0.13
SD	0.52	0.28	0.25	0.18
Min	1.04	0.00	0.00	0.00
Max	2.88	0.74	0.63	0.49
Control group				
Mean	1.85	0.16	0.19	0.17
SD	0.50	0.22	0.20	0.19
Min	0.99	0.00	0.00	0.00
Max	2.91	0.61	0.54	0.45
p	0.68	0.51	0.97	0.82
Vertical distance between the perpendicular projection of the peak point on the implant bevel plan and the top of the bone crest				
Test group				
Mean	1.83	1.19	1.19	1.18
SD	0.13	0.12	0.11	0.09
Min	1.61	1.01	1.03	1.04
Max	2.11	1.45	1.34	1.37
Control group				
Mean	1.76	1.12	1.15	1.14
SD	0.11	0.15	0.15	0.10
Min	1.58	0.92	0.90	0.93
Max	1.95	1.38	1.34	1.30
p	0.08	0.06	0.29	0.19

assess the bone remodeling of the postextractive socket. The machine (Kodak 9000 3D, Carestream Health, Rochester, NY, USA) with the lowest effective dose per examination (5.3 µSv), an adequate field of view (FOV) for a single implant case (small FOV: 50 × 37 mm), and the highest resolution achievable at the time of the study start-up (76 µm) were then selected. An analysis of the soft tissue dimensional changes was also performed using digital photographs.

A moderate recession of 0.32 ± 0.13 mm for the test group and 0.32 ± 0.16 mm for the control group was found at the facial aspect at the 6-month follow-up. At the same time, a common moderate growth of the papilla was observed at the mesial and the distal sites in both groups. A statistically significant difference was found at the facial site between the two groups at the subsequent follow-up, as the cases included in the control procedure experienced an increased recession of

TABLE 4 Distal Site Measurements

	T0	T1	T2	T3
Horizontal distance between the implant surface and the inner wall of the socket				
Test group				
Mean	0.94	−0.22	−0.23	−0.22
SD	0.32	0.21	0.24	0.24
Min	0.34	−0.64	−0.67	−0.63
Max	1.41	0.07	0.15	0.11
Control group				
Mean	0.98	−0.21	−0.08	−0.10
SD	0.33	0.27	0.20	0.22
Min	0.43	−0.58	−0.56	−0.44
Max	1.58	0.19	0.20	0.21
p	0.69	0.95	0.01	0.04
Vertical distance between the implant bevel level and the first point of contact of the bone with the implant surface				
Test group				
Mean	2.14	0.09	0.08	0.10
SD	0.48	0.21	0.18	0.16
Min	1.21	0.00	0.00	0.00
Max	2.95	0.62	0.70	0.41
Control group				
Mean	1.85	0.14	0.15	0.16
SD	0.50	0.21	0.23	0.18
Min	1.04	0.00	0.00	0.00
Max	2.88	0.62	0.05	0.49
p	0.92	0.42	0.36	0.31
Vertical distance between the perpendicular projection of the peak point on the implant bevel plan and the top of the bone crest				
Test group				
Mean	1.81	1.09	1.05	1.04
SD	0.12	0.12	0.14	0.07
Min	1.63	0.88	0.83	0.91
Max	2.14	1.27	1.25	1.19
Control group				
Mean	1.71	0.98	1.03	1.03
SD	0.12	0.12	0.12	0.08
Min	1.49	0.83	0.82	0.78
Max	1.88	1.19	1.19	1.17
p	0.03	0.02	0.33	0.57

soft tissue. The amount of this recession was found to be 0.59 ± 0.21 mm from baseline, a value in concordance with the findings of the papers that were used as benchmarks for the measurements of our study.[9,10,12] Our study was unable to find a connection between the amount of buccal recession and the biotype of the patient. The cases classified as *thin biotype* experienced indeed more recession, 0.41 ± 0.13 mm for the test group ($n = 11$) and 0.64 ± 0.22 mm for the control group ($n = 12$), compared with the cases classified as *thick biotype*, 0.31 ± 0.1 mm for the test group ($n = 13$) and 0.56 ± 0.2 mm for the control group ($n = 17$). This difference was, however, not statistically significant (test group: $p = .12$; control group: $p = .38$). The implant was placed palatally and subcrestally using a flapless protocol. This approach avoided the factors clearly identified

TABLE 5 Soft Tissue Remodeling

	T0	T1	T2	T3
Buccal site				
Test group				
Mean	0.28	0.32	0.33	0.35
SD	0.13	0.13	0.12	0.12
Min	0.08	0.09	0.10	0.16
Max	0.59	0.53	0.52	0.64
Control group				
Mean	0.27	0.32	0.57	0.59
SD	0.16	0.16	0.17	0.21
Min	0.09	0.05	0.23	0.13
Max	0.81	0.89	0.88	0.95
Distal site				
Test group				
Mean	0.29	0.02	−0.08	−0.10
SD	0.12	0.13	0.16	0.17
Min	0.10	−0.22	−0.34	−0.36
Max	0.50	0.18	0.13	0.12
Control group				
Mean	0.26	−0.01	0.02	0.03
SD	0.14	0.19	0.22	0.13
Min	0.05	−0.25	−0.34	−0.27
Max	0.50	0.38	0.49	0.24
Mesial site				
Test group				
Mean	0.26	−0.05	−0.08	−0.08
SD	0.12	0.13	0.12	0.16
Min	0.05	−0.25	−0.27	−0.35
Max	0.46	0.20	0.12	0.10
Control group				
Mean	0.28	0.02	−0.03	−0.01
SD	0.11	0.20	0.20	0.18
Min	0.07	−0.25	−0.35	−0.33
Max	0.48	0.45	0.40	0.38

by a recent literature revision[13] as predictors increased the likelihood for midfacial recession and incomplete papillae healing, such as the buccal position of the implant shoulder and the surgical approach with bone ridge recontouring. The soft tissues collapse as a consequence of standard impression taking at a deeper tissue levels could be identified as a causal factor for the recession assessed following the placement of the permanent crown, especially in the control group. No statistically significant difference between the prosthetic approaches used in this study was observed in terms of resulting vertical healing of the socket peaks. A common trend of moderate vertical resorption was observed in all the four measurement sites in both groups. The buccal site experienced an increased vertical loss, 0.96 ± 0.14 mm for the test group and 0.98 ± 0.13 mm for the control group, compared with the mesial, the distal, and especially the palatal sites, with the latter losing 0.28 ± 0.18 mm for the test group and 0.3 ± 0.16 mm for the control group. This result is in concordance with the findings of Botticelli and colleagues[14] and Sanz and colleagues.[15] The first author reported buccal hard tissue dimension reduction of 1.9 ± 0.9 mm compared to a 0.9 ± 0.6 mm change at the palatal aspect, while the second author reported a short term hard tissue resorption of 1 ± 2 mm at the buccal aspect compared to 0.5 ± 1.5 mm at the palatal aspect of the ridge.

The measurements of the vertical distance between the implant bevel level and the first point of contact of the bone with the implant surface gave some encouraging results. Taking into consideration all the measurement sites, an average vertical gap filling of 91% and 88% were respectively found for the test and control group at the 2-year follow-up. In the buccal sites those values respectively rose to 96% and 95%. Comprehensively, this is a good result in light of the assessments previously reported by Botticelli and colleagues[14] and

TABLE 6 Analysis of the Buccal Recession Expressed in Millimeter at the Two-Year Follow-Up

	Test Group		Control Group	
	Thin Biotype ($n = 11$)	Thick Biotype ($n = 13$)	Thin Biotype ($n = 12$)	Thick Biotype ($n = 17$)
Mean	0.41	0.31	0.64	0.56
SD	0.14	0.11	0.22	0.20
Min	0.24	0.16	0.18	0.13
Max	0.64	0.44	0.95	0.86

Sanz and colleagues,[15] as authors reported a 67% vertical gap filling. The result of our study is, however, strongly influenced by the initial dimensions of the gap. An analysis of the filling in of the palatal area, where the initial vertical gap was notably lower, evidenced at the same follow-up a result of 81% for the test group and 77% for the control group.

Major differences were, indeed, found in the measurement of the horizontal distance between the implant surface and the inner wall of the socket. No significant difference was found until the removal of the temporary abutment at the 6-month follow-up. At this stage, an average implant platform bone overgrowth of nearly 0.2 mm in both groups was evidenced. However, at the subsequent follow-up measurement, an increased resorption of hard tissue was observed in the control group. Comparing the data of the 2-year follow-up with that of the 6-month follow-up, the buccal sites lost 0.20 mm, the mesial sites lost 0.16 mm, and distal sites lost 0.11 mm. It must be clearly stated that loss, although statistically significant, did not jeopardize or affect the general clinical outcome of the treatment. However, the use of the test protocol caused, respectively, 71, 67, and 52% loss of bone contact with the implant platform. A similar amount of bone loss was also reported by Canullo and colleagues[16] in a recent paper that confronted the immediate positioning of the definitive abutment with the repeated temporary abutment replacement in postextractive implants. Our assessments are in keeping with the data reported in a previously published paper regarding a study where the authors applied the same test protocol for healed sites[6] and confirmed that, in the medium term, the nonremoval of abutments placed at the time of the surgery maintains the good healing results achieved immediately after surgery. Using a subcrestal approach, the neck of the immediate abutment is placed in a biological site that has an excellent blood supply and is rich in healing and osteogenetic factors created as a consequence of surgery.[17] The size of this abutment in its subcrestal portion has to be kept to a minimum, in keeping with the platform shift/switch technique.[18–21] This procedure creates a three-dimensional peri-implant biological space, a "chamber." This chamber is defined by a floor (the implant platform), the lateral walls (the four sides of the extraction site), and a ceiling (the lower side of the immediate temporary crown). The results of this study suggest that if the three-dimensional biological equilibrium created in this space around the shaft of the abutment and the implant platform is altered by removal of the abutment during the healing phase, a certain amount of bone resorption and facial tissue recession is triggered. This procedure indeed jeopardizes the favorable adhesion of the thick soft and hard tissues to the titanium surfaces of the implant-abutment area[21] that has been observed in histological studies.[22,23] The assessments of our paper are in concordance with the findings of Becker and colleagues[24] that reported an increased apical extension of the junctional epithelium and an increased bone resorption after repeated abutment disconnection/reconnection at 4 and 6 weeks after surgery. Indeed, the results of the early study of Abrahamsson and colleagues[25] seems to be confirmed, as those authors reported that the repeated removal of the abutment compromised the mucosal barrier and lasted in additional marginal bone resorption as a result of soft tissue reactions.

CONCLUSIONS

The nonremoval of abutments placed at the time of surgery improves the stability of soft and hard tissues healed around single immediately restored, subcrestally placed tapered maxillary implants.

ACKNOWLEDGMENTS

The authors would like to thank Mr. Gianluca Sighinolfi, dental technician in private practice, Bologna, Italy, for his invaluable technical support.

The authors have no commercial or financial relationship that may pose a conflict of interest or potential conflict of interest.

REFERENCES

1. Hammerle CH, Chen S, Wilson TG. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. Int J Oral Maxillofac Implants 2004; 19 S:26–28.
2. Lazzara RJ. Immediate implant placement into extraction sites: surgical and restorative advantages. Int J Periodontics Restorative Dent 1989; 9:332–343.
3. Roos-Jansaker AM, Lindahl C, Renvert H, Renvert S. Nine to fourteen-year follow-up of implant treatment. Part I: implant loss and associations to various factors. J Clin Periodontol 2006; 33:283–289.
4. Stein AE, McGlmphy EA, Johnston WM, Larsen PE. Effects of implant design and surface roughness on crestal bone and

soft tissue levels in the esthetic zone. Int J Oral Maxillofac Implants 2009; 26:941–946.
5. Weng D, Nagata MJ, Bosco AF, de Melo LG. Influence of microgap location and configuration on radiographic bone loss around submerged implants: an experimental study in dogs. Int J Oral Maxillofac Implants 2011; 24:910–919.
6. Degidi M, Nardi D, Piattelli A. One abutment at one time: non-removal of an immediate abutment and its effect on bone healing around subcrestal tapered implants. Clin Oral Implants Res 2011; 22:1303–1307.
7. National Council on Radiation Protection and Measurements. Implementation of the principle of as low as reasonably achievable (ALARA) for medical and dental personnel NCRP report no. 107. Bethesda, MD: NCRP, 1990.
8. Olsson M, Lindhe J. Periodontal characteristics in individuals with varying form of the upper central incisors. J Clin Periodontol 1991; 18:78–82.
9. Kan JY, Rungcharassaeng K, Umezu K, Kois JC. Dimensions of peri-implant mucosa: an evaluation of maxillary anterior single implants in humans. J Periodontol 2003; 74:557–562.
10. Kan JY, Rungcharassaeng K, Lozada JL. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. Int J Oral Maxillofac Implants 2003; 18:31–39.
11. Degidi M, Daprile G, Nardi D, Piattelli A. Buccal bone plate in immediately placed and restored implant with Bio-Oss(®) collagen graft: a 1-year follow-up study. Clin Oral Implants Res 2012; Aug 13. doi: 10.1111/j.1600-0501.2012.02561.x. [Epub ahead of print].
12. Kan JY, Rungcharassaeng K, Lozada JL, Zimmerman G. Facial gingival tissue stability following immediate placement and provisionalization of maxillary anterior single implants: a 2- to 8-year follow-up. Int J Oral Maxillofac Implants 2011; 26:179–187.
13. Cosyn J, Sabzevar MM, De Bruyn H. Predictors of interproximal and midfacial recession following single implant treatment in the anterior maxilla: a multivariate analysis. J Clin Periodontol 2012; 39:895–903.
14. Botticelli D, Berglundh T, Lindhe J. Hard-tissue alterations following immediate implant placement in extraction sites. J Clin Periodontol 2004; 31:820–828.
15. Sanz M, Cecchinato D, Ferrus J, Pjetursson EB, Lang NP, Lindhe J. A prospective, randomized-controlled clinical trial to evaluate bone preservation using implants with different geometry placed into extraction sockets in the maxilla. Clin Oral Implants Res 2010; 21:13–21.
16. Canullo L, Bignozzi I, Cocchetto R, Cristalli MP, Iannello G. Immediate positioning of a definitive abutment versus repeated abutment replacements in post-extractive implants: 3-year follow-up of a randomised multicentre clinical trial. Eur J Oral Implantol 2010; 3:285–296.
17. Cardaropoli G, Araújo M, Lindhe J. Dynamics of bone tissue formation in tooth extraction sites. An experimental study in dogs. J Clin Periodontol 2003; 30:809–818.
18. Hürzeler M, Fickl S, Zuhr O, Wachtel HC. Peri-implant bone level around implants with platform-switched abutments: preliminary data from a prospective study. J Oral Maxillofac Surg 2007; 65 S1:33–39.
19. Degidi M, Iezzi G, Scarano A, Piattelli A. Immediately loaded titanium implant with a tissue stabilizing/maintaining design ("beyond platform switch") retrieved from man after 4 weeks: a histological and histomorphometrical evaluation. A case report. Clin Oral Implants Res 2008; 19:276–282.
20. Luongo R, Traini T, Guidone PC, Bianco G, Cocchetto R, Celletti R. Hard and soft tissue responses to the platform-switching technique. Int J Periodontics Restorative Dent 2008; 28:551–557.
21. Kim H, Murakami H, Chehroudi B, Textor M, Brunette DM. Effects of surface topography on the connective tissue attachment to subcutaneous implants. Int J Oral Maxillofac Implants 2006; 21:354–365.
22. Schierano G, Ramieri G, Cortese M, Aimetti M, Preti G. Organization of the connective tissue barrier around long-term loaded implant abutments in man. Clin Oral Implants Res 2002; 13:460–464.
23. Degidi M, Perrotti V, Shibli JA, Novaes AB, Piattelli A, Iezzi G. Equicrestal and subcrestal dental implants: a histologic and histomorphometric evaluation of nine retrieved human implants. J Periodontol 2011; 82:708–715.
24. Becker K, Mihatovic I, Golubovic V, Schwarz F. Impact of abutment material and dis-/re-connection on soft and hard tissue changes at implants with platform-switching. J Clin Periodontol 2012; 39:774–780. doi: 10.1111/j.1600-051X.2012.01911.x
25. Abrahamsson I, Berglundh T, Lindhe J. The mucosal barrier following abutment dis/reconnection. An experimental study in dogs. J Clin Periodontol 1997; 24:568–572.