Marginal Bone Preservation in Single-Tooth Replacement: A 5-Year Prospective Clinical Multicenter Study

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ABSTRACT

Background: Few long-term studies are available comparing immediate and conventional loading protocols of implant-supported single-tooth replacement.

Purpose: The aim of the present randomized controlled clinical trial was to evaluate prospectively the 5-year clinical and radiological outcome of immediate functional loading implants used in single-tooth replacement.

Materials and Methods: One hundred fifty-one subjects, who required single-tooth rehabilitation in the area from position 15 to 25 and from 35 to 45, were enrolled in eight private clinics in Italy. A randomization protocol was applied to allocate the implants in three treatment groups: one control group and two test groups. In the control group, implant placement was performed according to a conventional drilling procedure, and the implants were submerged for 3 months before abutment connection and loading. Implants allocated in the test group 1 and 2 followed an immediate functional loading protocol. While in test group 1, implant placement was performed according to conventional drilling procedure, in test group 2, a modified implant installation procedure (osteotome technique) was applied. Clinical and radiographic examinations were performed during the 5-year follow-up, and technical and biological complications were registered.

Results: Although four implants (three in the test group 2 and one in the test group 1) were lost in the immediate functional loading groups in the first year of follow-up, no further implant loss occurred in any of the treatment groups in the following monitoring period up to 5 years. No significant differences on marginal bone level changes were observed between the treatment groups. About 52% of all implants showed bone gain in the period from 1-year to 5-year follow-up. The percentage of all implants that in the same interval of time showed bone loss was about 28%. Although few technical complications were recorded in the period of time up to 5 years, implants showing biological complication were 5.7%.

Conclusion: It is suggested that implants installed with a conventional installation technique together with an immediate functional loading protocol may be considered as a valid treatment alternative in a long-term perspective when used in a single-tooth replacement in an esthetic area.

KEY WORDS: bone loss, dental implants, immediate loading, OsseoSpeed, single tooth

INTRODUCTION

One of most undesirable complications in an immediate functional loading protocol in implant dentistry is the lack of osseointegration that leads to an early loss of the implant. This event is usually detected within the first 3 to 4 months of healing from implant installation. Hence, studies evaluating the predictability of such protocols have usually included follow-up period up to 1 year. Although the critical question of an immediate functional loading protocol in implant dentistry may be met using short period of follow-up (i.e., 1 year), the information that is retrieved from a randomized controlled

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DOI 10.1111/cid.12117

multicenter clinical trial of a specific type of oral rehabilitation (i.e., single-tooth replacement in an esthetic area) over longer periods than 1 year is pertinent. There is a growing amount of information in the literature regarding long-term follow-up of the clinical performance of dental implants in single-tooth replacement. Most reports, however, are observational studies on case series based on a limited number of subjects/implants. Thus, in a recent systematic review on 5-year survival rates of implant-supported single-tooth replacement,[1] 17 (65.4%) out of the 26 studies selected for the analysis had a sample size of <50 implants. In the VIII European Federation of Periodontology workshop on quality reporting of clinical research in implant dentistry, the relevance and the need of well-designed randomized clinical trial (i.e., RCT) for comparative research was emphasized.[2] Thus, a randomized controlled multicenter clinical trial with a 1-year follow-up was recently published aiming at comparing immediate functional loading protocols with a conventional, delayed loading protocol in single-tooth replacement.[3] The short-term results demonstrated that immediate functional loading implants installed with conventional surgical preparation technique (i.e., drill preparation) may be considered as a valid treatment alternative when applied for single-tooth replacement in an esthetic area.

Here, we report on the clinical and radiological outcomes in a 5-year prospective study on patients who received implants for single-tooth replacement in an esthetic area using immediate functional or conventional loading in a randomized controlled clinical trial design.

MATERIAL AND METHODS

One hundred fifty-one subjects (70 males and 81 females), who required single-tooth rehabilitation in the area from position 15 to 25 and from 35 to 45, were enrolled in eight private clinics in Italy. The ethical review board at the University of Perugia approved the study protocol and all subjects, before the start of the treatment, received detailed information on the study and signed a written consent. At the time of the recruitment, the mean age of the subjects was 46.7 (SD 18.3) for males and 44.2 (SD 12.9) for females. One hundred forty-one subjects had one implant placed, whereas 10 subjects received two implants in different jaw quadrants. The study design was reported in the published article by Donati and colleagues.[3] In brief, a randomization protocol was applied to allocate the implants in three treatment groups: one control group and two test groups. In the control group, implant placement was performed according to a conventional drilling procedure following the standards described in the manual for surgical procedures of the implant system (Astra Tech Dental, Mölndal, Sweden). The implants were submerged for 3 months before abutment connection and loading. In test group 1 and in test group 2, an immediate functional loading protocol of the implant was applied. Although a standard preparation procedure for the implant placement was used in the test group 1, a modified implant installation procedure using an osteotome technique (osteotome TM, Astra Tech Dental) was performed in the test group 2. All implants used in the current study were OsseoSpeed™ (Astra Tech Dental) Ø 4.0 or Ø 4.5 with lengths varying between 8 and 13 mm.

After the completion of the rehabilitation, the patients entered a 6-month re-call system for monitoring oral hygiene condition. Clinical and radiographic examinations at 3, 12, and 60 months of follow-up were performed at all sites. The clinical examinations included the assessment of plaque, bleeding on probing (BoP) and probing pocket depth (PPD) at four sites of each implant. In addition, the width of the keratinized mucosa and the height of the mesial and distal papilla of the peri-implant mucosa were also evaluated. Standardized intraoral radiographs (Kodak Ektaspeed Plus, Eastman Kodak Co., Rochester, NY, USA) were obtained using a parallel technique with custom-made film holders at implant installation and at 3, 12, and 60 months of follow-up. An experienced radiologist, who was blinded with regard to treatments groups, carried out the measurements in radiographs. Thus, the distance between the abutment/fixture junction and the marginal bone to implant contact was determined at the mesial and distal aspects of the implants with the use of a magnifying lens (×7). Technical complications such as abutment screw loosening, abutment screw fracture, implant fracture, loss of retention of the permanent crown (i.e., fracture of the luting cement), or fracture of the veneer material (i.e., ceramic or acrylic) were recorded during the 5-year period of observation.

Statistical Analysis

Mean values, standard deviations, and cumulative frequencies were calculated for each variable. Primary

TABLE 1 Life-Table for the Number of Patients and Implants at the Various Time Intervals

			Reasons for Loss of Implants to Follow-Up		
Time Intervals	N° Patients	N° Implants	Not Fulfilling Inclusion Criteria	Dropout	Explanted
Implant placement	149	159	2 (Test 2)		
1 month	147	156			3 (Test 2)
3 months	145	154		1 (Control)	1 (Test 1)
6 months	145	154			
12 months	144	153		1 (Control)	
60 months	133	140		4 (Control)	
				3 (Test 1)	
				6 (Test 2)	

outcome variables were implant loss and marginal bone level changes. The Fisher's exact test was used to evaluate differences in frequencies of plaque, gingivitis, and PPD categories between the treatment groups as well as differences in implant loss between treatment groups and between implant types (4.0 vs 4.5). The Student–Newman–Keuls Test (analysis of variance) was applied to evaluate differences between the three treatment groups regarding marginal bone level changes and differences in soft tissue changes from 12 months to 60 months. Differences in marginal bone level changes between implant types (Ø 4.0 and Ø 4.5) were analyzed using the Student's *t*-test. Multilevel regression models were applied: i) to evaluate the influence of different variables on marginal bone level changes; and ii) to study correlation of clinical findings with marginal bone level changes. In all analysis, a p value of $<.05$ was considered to represent a statistical significance.

RESULTS

Subjects and implants attending the 5-year follow-up are reported in Table 1. Out of the one hundred fifty-one subjects recruited and one hundred sixty-one implants installed at baseline, one hundred thirty-three patients and one hundred forty implants were available for examination at 60 months. No further implant loss was recorded during the time interval between 12 months and 60 months in any of the three treatment groups. Eleven subjects (7.6%) and 13 implants (8.5%) dropped out from the study during the period from 1 year to 5 years follow-up. Out of the eleven patients who dropped out from the study during the period between 1 and 5 years, two patients with one implant each moved abroad. Another six patients, five with one implant each and one patient with two implants, discontinued the scheduled follow-up. In these patients, it was not possible to obtain radiographs. However, the clinical assessment confirmed the survival of the implants. Finally, one patient with one implant died before the last follow-up of the study and another patient with two implants was not longer reachable. The overall implant survival rate at 5 years was 95.6%. Table 2 reports the characteristic of patients attending the 5-year follow-up and the dropout group.

Technical Complications

A total of three technical complications occurred during the 5 years of observation. Two patients experienced loss of retention of the permanent crowns. One patient presented the complication in the central incisor position at 2-year follow-up, whereas the second patient lost retention of the crown at the second upper premolar at the 3 years of follow-up. Crowns were recemented, and no further complications were detected during the following period. One patient experienced fracture of the veneer material (i.e., ceramic) at the second upper

TABLE 2 Characteristics of Subjects Attending 5-Year Follow-Up and Subjects Dropped Out during the Period from 1 Year to 5 Years

	Subjects at 5-Year	Subjects Dropped Out
Age (SD)	43.5 (11.9)	46.1 (17.4)
Gender (F/M)	78/55	6/5
Smokers (Y/N)	34/99	0/11

TABLE 3 Clinical Measurements at 1-Year and 5-Year Follow-Up. Frequencies (%) of Sites with Plaque and BoP+

		% 1 Year	% 5 Years
Plaque	Mesial	5.2	21.4
	Buccal	7.2	8.6
	Distal	9.2	17.9
	Lingual/palatal	5.9	13.6
Bop+	Mesial	7.8	15.7
	Buccal	6.5	10.0
	Distal	9.2	18.6
	Lingual/palatal	2.6	7.9

TABLE 4 Clinical Measurements, Changes in the Papilla Height (Mesial and Distal), and Width of Keratinized Mucosa from 1 Year (T12) to 5 Years (T60). Mean Values and Standard Deviation

	Mesial Papilla	Distal Papilla	Keratinized Mucosa
Test 1	−0.08 ± 0.90	−0.02 ± 1.05	0.02 ± 1.10
Test 2	−0.04 ± 0.93	−0.16 ± 1.05	0.25 ± 0.67
Control	−0.13 ± 0.98	−0.18 ± 0.86	0.0 ± 1.00

Student–Newman–Keuls Test; *p* value NS.

premolar at 3-year follow-up. The crown was rapaired, and no further complications was recorded up to 5 years of follow-up.

Clinical Findings

Table 3 and Figure 1 describe the clinical conditions (i.e., percentage of sites with plaque, BoP+ and PPD categories) at the 1-year and 5-year follow-up. An increase of implant sites that harbored plaque and were positive to BoP was observed at 5-year follow-up. The increase of plaque and BoP was similar at sites exposed to immediate loading or conventional loading. Proximal peri-implant sites showed higher frequencies of both plaque and BoP compared with buccal and palatal/lingual sites. Hence, at the 5-year reexamination, 19.6% of mesial and distal sites were found to harbor plaque, whereas 11.1% of the buccal and lingual/palatal sites showed plaque. BoP was found in 17.1% of proximal sites and in 8.9% of buccal and lingual/palatal sites. About 90% of the buccal and lingual/palatal sites had a probing depth ≤3 mm, whereas the corresponding frequency at the proximal sites was about 70%. A PPD of ≥6 mm was observed at 3.6% of the mesial and distal sites and 2.8% of the buccal and lingual/palatal sites. The statistical analysis (i.e., Fisher's exact test) failed to demonstrate significant differences between treatment groups with regard to clinical measurements.

Soft Peri-Implant Tissue Dimension

The results from the assessment of the soft peri-implant tissue dimension are reported in Table 4. No significant differences were detected between treatment groups in relation to changes of papilla height or to the width of the keratinized mucosa over the 5 years of follow-up. The height of the soft tissue papillas increased in all the three treatment groups from baseline to 5-year follow-up of about 0.2 to 0.3 mm. On the other hand, the width of the keratinized mucosa decreased about of 0.1 mm in the controls and the test group 1 and 0.3 mm for the test group 2.

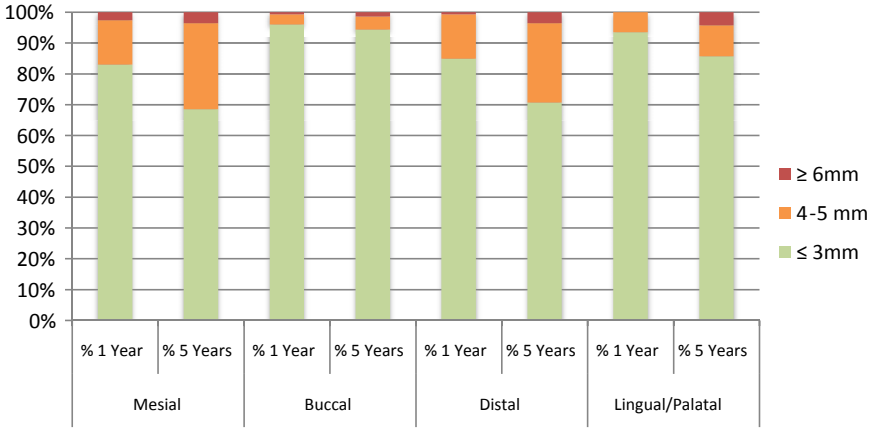

Figure 1 Clinical measurements at 1-year and 5-year follow-up. Frequencies (%) of PPD categories.

TABLE 5 Marginal Bone Level Changes from 1 Year (T12) to 5 Years (T60) according to Treatment Groups. Mean Values and Standard Deviation

Time Interval	Test 1		Test 2		Control		Student–Newman–Keuls Test
	Mesial	Distal	Mesial	Distal	Mesial	Distal	
T12–T60	−0.06 (± 1.0)	−0.05 (± 0.9)	−0.20 (± 0.63)	−0.02 (± 1.21)	−0.15 (± 0.76)	−0.10 (± 1.07)	NS

Bone Level Change

Table 5 describes the marginal bone level changes between 1 year and 5 years according to the treatment groups. Table 6 reports the marginal bone level changes between 1 year and 5 years with regard to implant type (Ø 4.0 conical vs Ø 4.5 cylindrical). No significant differences on marginal bone level changes were observed between the treatment groups and between implant types during the time interval from 1 to 5 years. Figure 2 illustrates the mean peri-implant bone loss for the three treatment groups from baseline to 5-years follow-up. After 60 months, the mean marginal bone loss was 0.26 ± 1.22 for the control group, 0.30 ± 0.91 for the test group 1, and 0.29 ± 1.31 for the test group 2. The differences between the three treatment groups were not statistically significant. A larger amount of bone loss of 0.2 to 0.33 mm occurred in the early healing phase, that is, within the first 3 months, regardless of the type of the treatment group. Peri-implant marginal bone level changes after 3 months to 1 year varied between −0.09 and +0.02 mm. In the time interval between 1-year and 5-year follow-up, implants of the control group and test group 1 showed a mean bone gain of 0.12 mm and 0.02 mm, respectively, whereas implants of the test group 2 demonstrated a mean bone loss of 0.04 mm. The cumulative percentage distribution of implants according to bone level change between 1-year and 5-year follow up is presented in Figure 3. About 52% of all implants showed bone gain in the period from 1-year to 5-year follow-up (Figure 4). The largest amount of bone gain was 1.80 mm (control: 1.60 mm, test 1: 1.80 mm, test 2: 1.0 mm). The percentage of all implants that in the same interval of time showed bone loss was about 28%. The largest amounts of bone loss were 3.20 mm for the control group, 3.80 mm for test 1, and 3.80 mm for test 2 groups.

Table 7 reports the number and percentage of patients and implants that at the 5-year follow-up showed BoP positive and demonstrated bone loss ≥1 mm or ≥2 mm after year 1. The percentage of implants affected by BoP+ and bone loss of ≥1 mm or ≥2 mm in relation to the number of implants available for the analysis at 5-year follow-up was 5.7% and 2.9%, respectively. The corresponding figures in relation to patients were 6% and 3%, respectively.

Multilevel Regression Models

Table 8 describes the results for the multilevel regression model applied to identify variables influencing the marginal bone level changes. Thus, explanatory variables such as treatment groups, implant types, smoking habits, and "tooth" position of the implant and plaque were introduced and tested stepwise. Only the presence of plaque was found to have a significant ($p = .03$) impact on the marginal bone level chances (i.e., bone loss) at 5-year follow-up. A second multilevel regression model (Table 9) was created to study the correlation of clinical and radiologic findings with marginal bone level changes. It was observed that PPD categories did not correlate with marginal bone level changes, whereas BoP+ showed significant correlation ($p = .02$) with

TABLE 6 Marginal Bone Level Changes from 1 Year (T12) to 5 Years (T60) according to Implant Type. Mean Values and Standard Deviation

Time Interval	Type of Implants		*t*-Test
	4.0	***4.5***	
T12–T60	−0.08 ± 0.60	−0.01 ± 1.0	NS

TABLE 7 Peri-Implantitis Cases. Number and (%) of Patients and Implants Affected according to Bone Loss Thresholds

	BoP+ BL ≥2 mm	BoP+ BL ≥1 mm
Patients	4 (3%)	8 (6%)
Implants	4 (2.9%)	8 (5.7%)

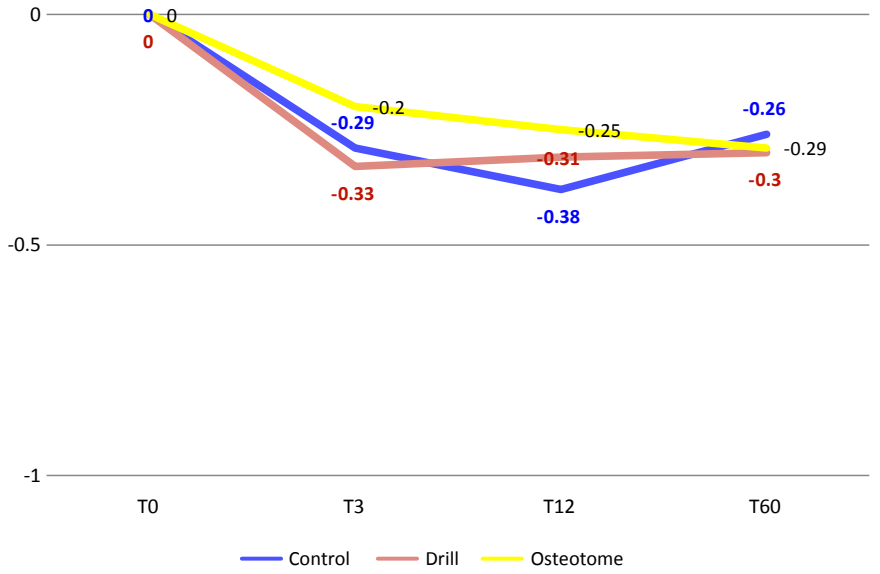

Figure 2 Peri-implant bone loss from baseline to 5-year follow-up.

changes of the marginal bone level. The analysis furthermore revealed that implant sites that at 1-year follow-up showed marginal bone loss were correlated with bone gain at 5-year follow-up ($p = .04$).

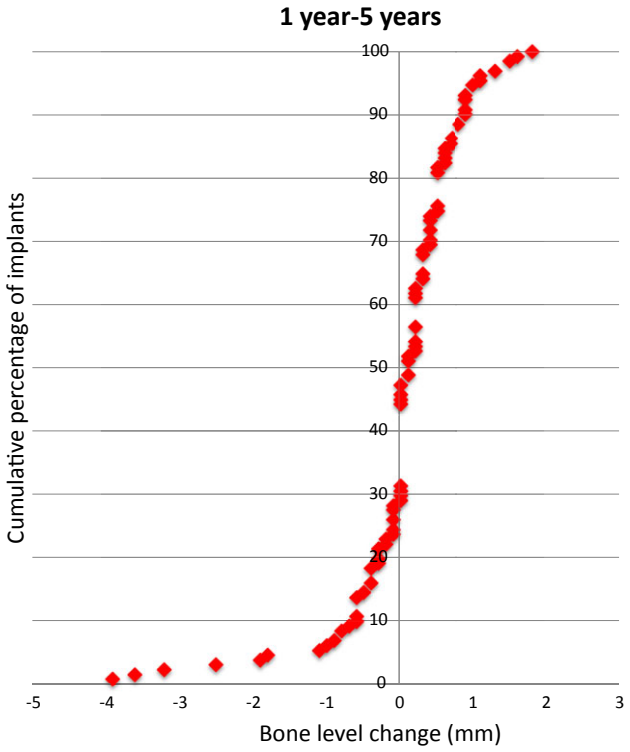

Figure 3 Cumulative percentage distribution of implants according to bone level change between 1-year and 5-year follow-up visits.

DISCUSSION

The present clinical investigation was carried out to study the long-term follow-up of immediate functional loading implants used in single-tooth replacement in an esthetic area. Two different surgical procedures (osteotomes vs conventional drill preparation) were applied for implant installation. Although four implants (three in the osteotome group and one in the conventional drill preparation group) were lost in the immediate functional loading groups in the first year of follow-up,[3] no further implant loss occurred in any of the treatment groups in the following monitoring period up to 5 years. Furthermore, no statistically significant differences in mean marginal bone loss were detected between the treatment groups. It is suggested that implants installed with a conventional installation technique together with an immediate functional loading protocol may be considered as a valid treatment alternative in a long-term perspective, when used in a single-tooth replacement in an esthetic area.

In regard to the results on implants supporting single crowns after 5 years of function, Jung and colleagues[1] in a review reported an overall survival rate of 96.8% obtained from the 26 studies representing different implant systems. These data are in line with the overall survival rate of 95.6% reported in the present trial. Further observations made in the current study corroborate findings reported on single-tooth

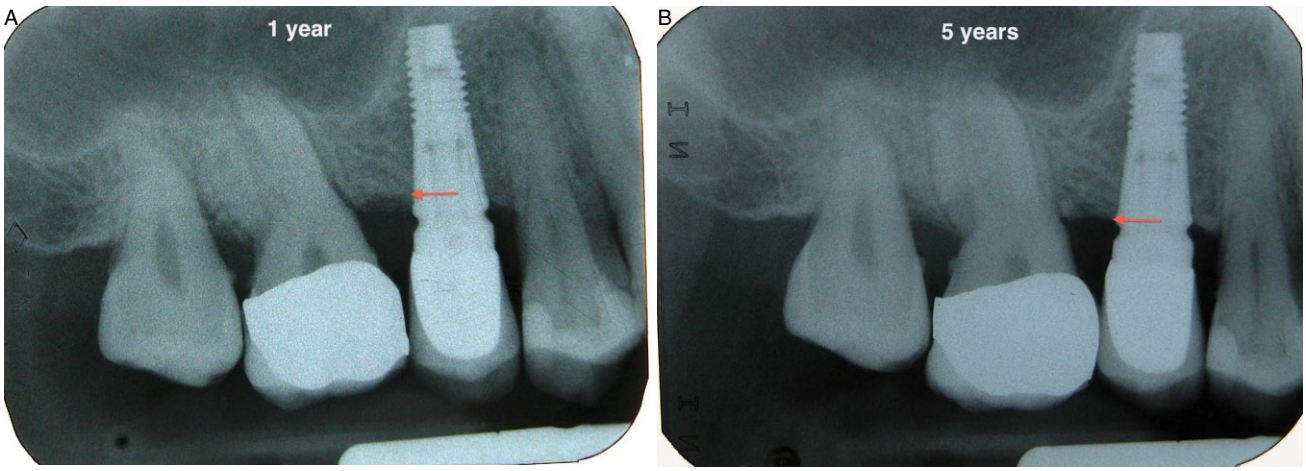

Figure 4 (A) Radiographic illustration of one of the implant/case showing bone gain after 1 year of follow-up. (B) Radiographic illustration of one of the implant/case showing bone gain after 5 years of follow-up.

replacement procedure using the same implant system. Thus, in a similar study comparing immediate, early and delayed loading regimens in single posterior implant sites, Barewal and colleagues[4] reported that the overall survival rate at 3-year follow-up was 97.5%, and the mean marginal bone loss was 0.33 and 0.22 for immediate and delayed loading implants, respectively. In a 5-year prospective study, Wennström and colleagues[5] evaluated the outcome of a single-tooth rehabilitation procedure in 40 subjects with 45 Astra Tech dental implants. It was demonstrated that the mean peri-implant bone loss that occurred from 1 year to 5 years of follow-up was around 0.08 mm. The corresponding mean peri-implant bone loss recorded in the current study in the same time interval (i.e., from 1 year to 5 years) was 0.05 mm. Gotfredsen[6] in a study on single implants placed in extraction sockets in 20 patients reported that the average bone loss that occurred between 1 year and 5 years of follow-up was 0.14 mm. In a similar study, Lee and colleagues[7] reported that the mean marginal bone loss that occurred at single-tooth implants from 1 year to 3 years of follow-up was 0.10 mm. In the studies by Gotfredsen[6] and Lee and colleagues[7] it was highlighted that the largest amount of

TABLE 8 Multilevel Regression Model. Marginal Bone Level Changes at 5 Years as Outcome Variable. Variables Influencing Marginal Bone Level Changes

	Null Model			Final Model		
Predictors	Value	SE	*p*	Value	SE	*p*
Implant type						ns
Treatment group						ns
Smoking						ns
Tooth position						ns
Plaque				−0.36	0.17	0.03
Intercept (β_0)	0.04	0.07		0.20	0.17	
Random part						
Implant var (u_{0jk})	0.45	0.09		0.43	0.09	
Site var (e_{0ijk})	0.50	0.06		0.52	0.07	
−2*loglikelihood		698.34 $p < .001$			665.68	
ICC					0.1	
R^2					0.01	

ICC = intraclass correlation; var = variance; SE = standard error; ns = not significant.

TABLE 9 Multilevel Regression Model. Marginal Bone Level Changes at 5 Years as Outcome Variable. Clinical and Radiographic Findings Correlating with Marginal Bone Level Changes

	Null Model			Final Model		
Predictors	Value	SE	*p*	Value	SE	*p*
Pocket category						ns
Mucositis				−0.48	0.20	0.02
Bone loss baseline – 1 year				−0.15	0.08	0.04
Intercept (β_0)	0.04	0.07		0.02	0.10	
Random part						
Implant var (u_{0jk})	0.45	0.09		0.48	0.10	
Site var (e_{0ijk})	0.50	0.06		0.50	0.07	
−2*loglikelihood		698.34 $p < .001$			665.68	
ICC					0.1	
R^2					0.01	

ICC = intraclass correlation; var = variance; SE = standard error; ns = not significant.

bone loss occurred from baseline to 1-year follow-up. This observation is consistent with data presented in the current study. In fact, the mean bone loss recorded between implant installation and 3 months was larger (0.27 mm) than the bone loss that occurred from 3 months up to 5 years (0.04 mm).

The finding that marginal bone loss is more pronounced in the early phase of the healing process was also presented in studies using different implant systems. Thus, Scheller and colleagues[8] reported that the bone loss that occurred around 97 Brånemark implants between crown installation and 1-year follow-up was 0.45 mm, whereas in the period between 1 year and 5 years, a small bone gain of 0.01 mm was recorded. Similarly, Bornstein and colleagues[9] in a study evaluating the long-term follow-up of single-tooth replacement with Straumann implants reported that the amount of bone loss occurring in the time period between crown placement and 1 year was 0.12 mm, whereas in the period between 1 and 5 years, the mean bone loss was 0.03 mm.

Although mean values of bone level changes provide an indicative description of the peri-implant hard tissue alteration, the cumulative percentage distribution of implants, losing or gaining bone, highlight the extent of negative or positive outcomes that influence the mean value. In the present study, it was observed that about 70% of all implants showed no bone loss in the period from 1-year to 5-year follow-up. In the study by Wennström and colleagues,[5] 48% of the implants showed no bone loss in the period from baseline (i.e., crown installation, 3 or 6 months after implant installation) to 5-years follow-up. The difference in percentage of implants showing no bone loss at the 5 years presented in the two studies may be explained by the different time intervals scheduled and the different implant installation procedure. Although all implants in the study by Wennström and colleagues[5] needed a second surgical procedure for abutment connection, 2/3 of the implants in the present trial sample were installed and restored with a single surgical/restorative procedure. According to the success criteria for implants presented by Albrektsson & Isidor,[10] maximum of 2.3 mm of bone loss after 5 years of function can be accepted. Hence, although Wennström and colleagues[5] reported that one implant out of 40 (2.5%) showed >2.3 mm of bone loss, four implants out of one hundred thirty-one (3.1%) in the current study demonstrated bone loss over 2.3 mm at 5-year follow-up.

In relation to the frequency of implants demonstrating bone loss after 5 years of follow up, data concerning biological complications that were presented in the review by Jung and colleagues[1] should be considered. In the 26 studies selected for the analysis, peri-implant mucosal lesions (i.e., soft tissue complications) occurred in 9.7% of the cases, whereas bone loss exceeding 2 mm over 5 years was found in 6.3% of the implants. Although the definition of soft tissue complications differed among the studies analyzed in the review, the data presented in the current trial are in line with the data presented by Jung and colleagues.[1] Thus, in the present study, it was observed that when a threshold of ≥1 mm

of radiographic bone loss and BoP+ was considered, 5.7% of the implants were detected as positive for this biological complication, whereas when the threshold of ≥2 mm of radiographic bone loss and BoP+ was applied, the percentage of implants affected by peri-implantitis was 2.9%. The biological complications data reported in the current trial, although apparently of low incidence, have to be considered in light of the relatively short time of follow-up (i.e., 1–5 years) scheduled for observation and under the condition that the patients received oral hygiene checkups regularly every 6 months up to the 5-year examination.

Multilevel multivariate regression models were applied in the current trial to study the influence of different variables on marginal bone level changes and to evaluate correlation of clinical findings with marginal bone level changes. Similar analysis was performed also in a previous study presenting the 1-year follow-up data.[3] Thus, in Donati and colleagues,[3] it was observed that the only variable influencing the marginal bone level changes was the *type of implant* installed (i.e., Ø 4.5 conical-shaped implant vs Ø 4.0 cylindrical-shaped implant). The corresponding 5-year follow-up data of the present investigation showed that the variable *type of implant* was no longer influencing the marginal bone level changes. It was observed that implants showing bone loss after 1 year of follow-up correlated with bone gain after 5 years of follow-up. These findings corroborate the hypothesis that the amount of peri-implant bone loss that occurred between time of installation, and 1 year is mostly of a surgical-traumatic origin and recovery of such loss may follow under proper oral hygiene conditions and maintenance. Furthermore, the multilevel multivariate model applied in the present investigation demonstrated that variables such as *type of treatment* (i.e., immediate loading vs delayed loading), *smoking* and *tooth position restored* did not influence the marginal bone level changes in the time interval between 1 year and 5 years, whereas the presence of plaque affected the bone level changes and that BoP+ correlated with peri-implant bone loss. Another relevant variable, such as PPD category (i.e., PPD category), was not correlated with bone loss. A possible explanation of this finding is related to the fact that the PPD was recorded not only from the mesial and distal sites but also from the buccal and lingual sites, whereas bone level changes in radiographs were restricted to mesial and distal aspects of the implant.

CONCLUSION

The results of this 5-year follow-up study revealed that the single-tooth rehabilitation in an esthetic area by means of dental implants may be considered as a predictive treatment alternative in the long-term follow-up, regardless of the type of loading protocol applied after installation. It was also observed that the amount of bone loss that occurred from 1-year to 5-year follow-up is limited and that the successful long-term outcome of implant supported single-tooth rehabilitation procedures is depending on the oral hygiene compliance.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Mauro Billi, private practice, Montevarchi, Italy; Dr. Biagio Di Dino, private practice, Monsumano, Italy; and Dr. Paolo Torrisi, private practice, Catania, Italy for their clinical contribution to this study; Prof. Kerstin Gröndahl, Department of Oral and Maxillofacial Radiology at Göteborg University for the radiographic analysis and Dr. Cristiano Tomasi, Department of Periodontology at Göteborg University for the assistance in the multilevel model analysis. This study was supported by grants from Astra Tech Dental, Mölndal, Sweden.

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