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RESEARCH PAPER

Retrospective Clinical Study of Marginal Bone Level Changes with Two Different Screw-Implant Types: Comparison Between Tissue Level (TE) and Bone Level (BL) Implant

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Abstract
Aim The objective of this retrospective cohort study was to compare the amount of marginal bone loss (MBL) in a bone-level and a soft-tissue-level implant system, both of which have similar intra-bony shape and surface composition. A subgroup analysis was done to compare the amount of MBL of each implant type in relation to the different vertical placement within the respective groups of implants.
Materials and Methods Records of all patients who underwent implantation for replacement of teeth using comparable bone level (BL) and soft tissue level implants (TE) from 1st January 2006 to 31st December 2009 were scrutinized. Initial depth of implant placement (IDIP) was measured for all implants. Marginal bone loss was measured in patients whose records were available at time point corresponding to 12, 24 and 36 months post insertion.
Results Out of a total of 384 implants, 337 implants were included for study. The mean MBL for the BL implants were 0.3, 0.38, 0.48 and for TE implant were 0.6, 0.54 and 0.93 for time periods 12, 24 and 36 months respectively. Although there was no statistically significant difference between the two groups at time periods at 6–12 months, in later time periods, there was a slightly greater amount of MBL around TE implants as compared to BL implants ($p < 0.001$). When comparing the IDIP and MBL in the same implant type, there was a statistically significant ($p < 0.001$) positive correlation between the depth of implant placement and the amount of MBL, with deeper placed implants having more bone loss.
Conclusion Within the limitations of this retrospective cohort study design, one can conclude that BL implants had statistically significant lesser MBL as compared to TE in time periods above 12 months. Although the difference is statistically significant, the difference may not be clinically significant. The IDIP had an influence on the amount of MBL, with deeper placed implants and screw structure of the implant placed below the bone, having more MBL in the period of study.

Keywords Marginal bone level · Bone loss · Retrospective clinical study · Bone level implant · Tissue level implant · Implant depth

The data from this study is part of the dissertation work submitted to Johannes Gutenberg University, Mainz as part of doctoral thesis of Dr. Vinay V. Kumar.

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Introduction

Maintenance of bony support around implants is of prime importance for successful outcome following implantation. From the 1980s, among the various criteria to assess implant success, amount of marginal bone loss over a period of time was an important factor [1]. Moreover the marginal bone reactions are very important in replacement of teeth in esthetic areas like maxillary anterior teeth in patients with a high lip line. Although the exact etiology of crestal bone changes around dental implants is not yet completely understood, many factors have been stated to influence this phenomenon [2, 3]. Among this, some of the important criteria were the type of implant (1 piece vs. 2 piece), the type of abutment (platform switch or matching platform—i.e. with or without a horizontal offset), the location of the implant–abutment junction (IAJ) in relation to the crest of the alveolus and the stability of the IAJ [4–6].

Studies show that supracrestal position of implant placement results in significantly lesser marginal bone reactions as compared to crestally placed implants [7]. With the concept of fixed biologic width, it has been proposed that soft tissue level implants with the IAJ coronal to the crestal bone level would result in minimal marginal bone resorption [8]. However, the concept of horizontal offset (platform switching) has made it possible to place implant shoulders at the crestal bone level with predictable minimal marginal bone resorption [9–11]. Certain studies also show bone deposition on the implant shoulder when implants with horizontal offset abutments were used with the IAJ in deeper subcrestal regions [12–15].

The objective of this retrospective study was to compare the amount of marginal bone loss in a horizontally offset implant system using a bone level implant-abutment interface, with a matching platform implant system using a soft tissue level implant-abutment interface; both of which have similar characteristics in terms of the intra-bony shape and surface composition (Fig. 1). A subgroup analysis was done to relate the amount of vertical marginal bone loss in relation to the IDIP in each of the two types of implants.

Fig. 1 The implants evaluated in the study. (*Left*) Tissue level TE implant, (*right*) Bone level BL implant

Materials and Methods

In this retrospective study, records of all patients who underwent implantation for replacement of teeth using Straumann BL implants (BL) and Straumann TE implants (TE) (Institute Straumann AG, Basel, Switzerland), from 1st January 2006 to 31st December 2009 in the Department of Maxillofacial and Plastic Surgery, University of Mainz were evaluated and scrutinized. Patient data were scrutinized for medical anamnesis, local risk factors as well as the treatment procedures followed. Age of the patient, the region of implantation, length and diameter of implant, type of implant used as well as the number and times of radiographic follow-up were all recorded.

Out of this patient data, the ones chosen for the study fulfilled the following inclusion criteria (which were noted from the patient records): patients with no medical condition that would jeopardize the implant treatment (such as uncontrolled diabetes, etc.), sound periodontal status, and adequate width of attached gingiva at the region of implant placement. All implants were placed into sockets at least after 3 months following their extraction. All surgical procedures were performed by the same surgical unit and all restorations were performed by the same prosthetic team. All personnel involved in the treatment of these cases had adequate training in advanced implantology to routinely perform these procedures. A two-staged technique was used for the installation of both the implants.

Exclusion criteria were implants with inadequate follow-up documentation (<12 months follow-up documentation and representation in <2 time periods) and documented medical problems that were detrimental to implant survival. Patients with simultaneous bone augmentation procedures were excluded from the study. Four TE implants and two BL implants failed (the reasons for which were not clearly stated in the case sheet) and were removed and these were excluded from the study.

The intention of the data collection for the study was to form similar sub groups of patients treated with the two different implant systems in statistically sufficient numbers to enable meaningful comparisons of marginal bone loss.

The Implants

The BL implant is inserted all the way down to the bone level, as the implants rough surface extends to the top of the implant and the connection is shifted inwards with an internal connection. The abutment connection for this system consists of a mechanically locking friction fit with a 15° taper, and four internal grooves. The abutment has a horizontal offset concept. The TE implant is placed with the rough surface of the implant up to the crestal bone. It has a smooth neck part of 1.8 mm projecting above the crestal bone. This implant system also uses an internal connection, and the abutment is fixed to an internal morse taper design (with 8° taper) (Fig. 2). However, the implant and the abutments have matching platforms.

Surgical Procedure

After a crestal incision, full thickness flaps were elevated minimally so as to aid in proper placement of implants. Osteotomy preparations were performed with low speed-high torque drill units (800 rpm) using copious irrigation with cold saline solution. The implants had been placed as per the instructions of the manufacturers, with the BL implants intended to be screwed at flush edge to the crestal bone, whereas, the TE implants were intended to be inserted up to the level of the screws, which left a smooth neck of 1.8 mm projecting above the bone level. Primary stability was achieved in every case. Antibiotics were not routinely administered but patients were advised to rinse with chlorhexidine. NSAID analgesics were given for pain relief. All implants were loaded approximately 3 months following implant placement although no efforts were made to calculate the exact time of loading.

Marginal Bone Level Measurements

Radiographic measurements of marginal bone loss were done using panoramic x-rays following the methods described previously [16–18]. The measurements with standardized intra-oral films were not possible in this retrospective study design.

The reference points for the measurements were the implant platform (the horizontal interface between the implant and the abutment) and the first bone-implant contact (FBIC). The initial depth of implant placement (IDIP) was measured in mm using the immediate post implantation radiograph. It was calculated as the distance between the reference line and the FBIC in the immediate post implantation radiograph. Marginal bone loss (MBL) amounts were measured as the difference in the marginal bone level at the particular time of follow-up and IDIP (baseline measurement). It was measured as the difference of the distance between reference line and the FBIC and the IDIP value. This method is diagrammatically represented in Figs. 3 and 4.

The follow-up radiographs were grouped into the following based on the time period post implant insertion: 12 months (6–12 months); 24 months (13–24 months); 36 months (25–36 months); and 48 months (37–48 months) post insertion.

Panoramic x-rays were analyzed with an image analyzing software (Image J 1.4q, National Institute of Health, USA). Implant depth measurements were taken for each implant individually. The radiographic picture was magnified and the level of crestal bone was assessed and measured at the mesial and distal margins of the implant by two independent examiners. In cases of discrepancy between the two measurements the site was viewed again and the values were discussed until an agreement could be found. The bone level changes were calculated both mesially and distally, based on the baseline and the follow-up measurements. The mean average of the mesial and distal measurements of each implant at each period of time was calculated and noted as average bone loss. An algorithm for implant insertion depth and marginal bone loss at different periods of time was established based on the average values.

Statistical Analysis

To compare the MBL at the different time points within two groups, a one-way analysis of variance (ANOVA) was conducted. p values <0.001 were termed significant. In a sub-group analysis, the IDIP was correlated with the MBL values in both the implant types at the different points of time mentioned above. Here, a two-tailed Pearson correlation coefficient was calculated and p values <0.001 were termed significant. The analyses were conducted using SPSS version 15.0 (SPSS, Chicago, Il., USA).

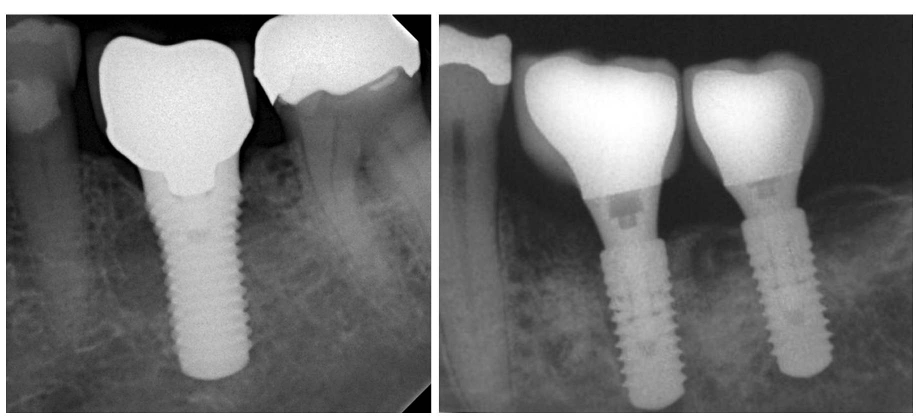

Fig. 2 Radiographs of TE (*Left*) and BL (*Right*) implants

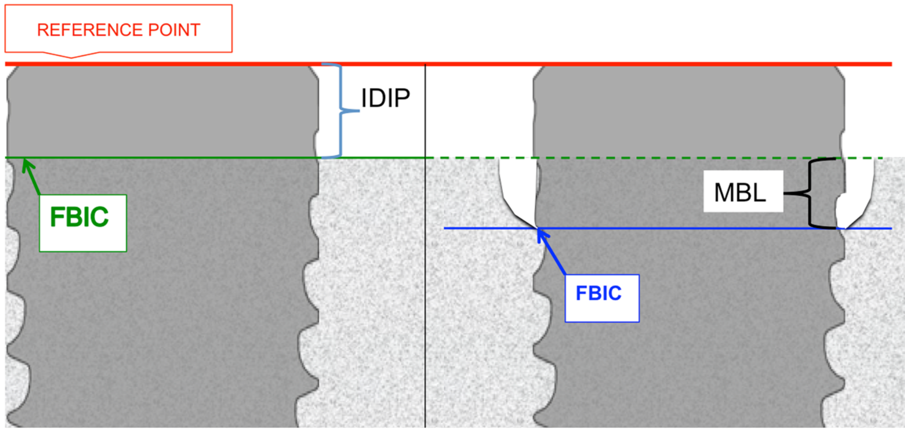

Fig. 3 Diagrammatic representation of the measurement of marginal bone level changes of BL implant. *Red line* denotes the reference line; *Green line* represents the FBIC at the time of placement and the *Blue line* represents the FBIC at the follow-up time period

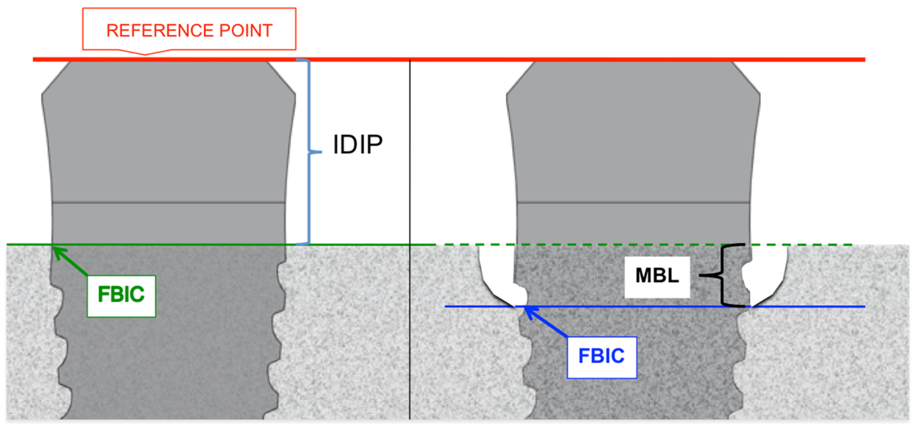

Fig. 4 Diagrammatic representation of the measurement of marginal bone level changes of BL implant. *Red line* denotes the reference line; *Green line* represents the FBIC at the time of placement and the *Blue line* represents the FBIC at the follow-up time period

Results

A total of 384 implants (185 BL and 192 TE) in 145 patients were placed in the time period under consideration, out of which 6 implants (2 BL and 4 TE) had failed and had to be removed. Only 337 implants (179 BL and 158 TE) inserted in 129 patients fulfilled the inclusion criteria and hence were included in the study. The year-wise break-up of the implants and patients are shown in Table 1. The distribution of implants based on the diameter and the length are provided in Table 2. The distribution of the region of implant replacement is provided in Table 3.

Table 4 enumerates the number of implants and patients that were evaluated at each time period of follow-up. The number of radiographs assessed are equal to the number of patients at each point of time as each patient underwent a single OPG at the particular time of follow-up.

Table 1 Year-wise distribution of implants (and patients in parenthesis)

Type/year	2009	2008	2007	2006	Total
BL	59 (18)	74 (26)	46 (19)	0 (0)	179 (63)
TE	26 (8)	21 (9)	40 (17)	71 (32)	158 (66)
Total	85 (26)	95 (35)	86 (36)	71 (32)	337 (129)

Table 2 Distribution of implants based on the (a) diameter, (b) length

	(a) Diameter (mm)		
	3.3	4.1	4.8
Number of implants			
BL	80	92	7
TE	34	105	19
Total	114	197	26

	(b) Length (mm)			
	8	10	12	14
Number of implants				
BL	5	69	100	5
TE	6	65	84	3
Total	11	134	184	8

The values of marginal bone loss (MBL) in the different time groups of follow-up: 1 year (6–12 months); 2 years (13–24 months); 3 years (25–36 months) and 4 years (37–48 months) are presented in Table 5 and Fig. 5.

Table 3 Distribution of the region of implant placement

	Region		
	Frontal	Premolar	Molar
Maxillary			
Number of implants			
BL	30	41	18
TE	19	45	33
Mandibular			
Number of implants			
BL	41	27	22
TE	10	16	35
Total	100	129	108

Table 5 The mean values of average marginal bone loss in the different time groups of follow up subdivided into types of implants

Follow-up groups	Bone loss mean in mm; (number of implants)				
	BL	TE	BL SD	TE SD	*p* value
6–12	0.3 (77)	0.61 (79)	0.431	1.13	0.28
13–24	0.38 (132)	0.54 (89)	0.233	0.462	0.001*
25–36	0.48 (56)	0.93 (43)	0.269	0.420	<0.0001*
37–48	0.33 (15)	1.11 (41)	0.098	0.748	<0.0001*

Standard deviations (SD) and respective *p* values are given. The number placed in parenthesis are the number of implants that were evaluated at each time point

Table 5 also provides the number of implants evaluated at each time period (mentioned in parenthesis). Statistical significant differences are marked with an asterisk.

When comparing the two groups (BL vs. TE), there was no statistically significant difference between the two groups at time periods at 6–12 and 13–24 months. However in the time period of 25–36 months, there was a slightly greater amount of marginal bone loss (MBL) around TE implants as compared to BL implants. Although this difference was statistically significant, the magnitude of the difference was not clinically relevant (<0.5 mm difference in the time group of 25–36 months).

The average initial depth of implant placement (IDIP) for both implants were as per the different concepts of the implants. The BL implants were inserted with the implant shoulder very near the crestal bone, (range: −0.71 to +0.78 mm; mean: +0.007 mm; SD 0.2); where del # as the TE implants were placed with the shoulder of the implant (above a machined collar part) 0.43 mm above crestal bone margin to 2.73 mm above crestal bone margin (mean: 1.65; SD: 0.33 mm).

Correlations between the IDIP and the MBL in both the systems at the different points of time are given in Table 5. In the BL group, there was a statistically significant positive correlation between the IDIP and MBL for time periods up to 36 months, with greater amount of marginal bone resorption at deeper placements. In the TE group, statistically significant positive correlation was found in the time group of up to 24 months (Table 6).

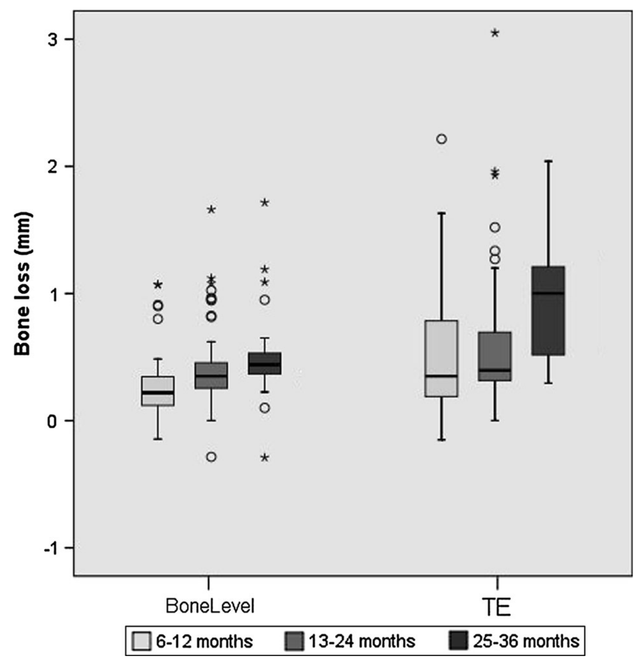

Fig. 5 *Box plot* diagram showing the amount of marginal bone loss of different implants in different time periods

Discussion

The principle of crestal bone remodelling (saucerisation) around a dental implant has been widely noted in the literature. The etiology of this bone loss can vary depending on the type of implant (one-piece vs. two-piece) and also

Table 4 Number of implants (and the number of patients) evaluated at each time point of the study

	Initial placement	Time period: 6–12 months	Time period: 13–24 months	Time period: 25–36 months	Time period: 37–48 months	Total
BL	179 (63)	77 (42)	132 (51)	56 (30)	15 (6)	459 (192)
TE	158 (66)	79 (44)	89 (48)	43 (26)	41 (19)	410 (203)
Total	337 (129)	156 (86)	221 (99)	99 (56)	56 (25)	869 (395)

on the type of abutment especially in case of two-piece implants. In this study, BL is a type of 2 piece implant with the IAJ at the level of crestal bone and uses a horizontal offset concept whereas, TE is a type of 2 piece implant, with the IAJ above the crestal bone, at the soft tissue level. Both the implant systems have a similar outer surface composition of the intra-bony component, and a similar intra-bony design of a cylindrical apex with a conical coronal taper. Both implant systems have a similar thread pitch. In both the subsets of patients implant surface, intra bony implant design, structure of the implant collar, timing of implant placement, timing of implant loading and mobility of the mucosa were similar. Hence this study could compare the effects of two variables in terms of implant depth from bone level and the difference of abutment design (bone level implant with horizontal offset vs. soft tissue level implant without horizontal offset) on the influence of marginal bone levels.

The results of the retrospective study showed that in both the systems there was minimal bone loss, and both systems had stable, acceptable marginal bone reactions. There was statistically significant lesser amount of marginal bone loss in BL implants as compared to TE implants, although the magnitude of the difference may not be clinically significant.

It has been observed in the literature that the use of a reduced diameter abutment connected to a wider diameter implant platform ('horizontal offset' or 'platform switching'), is associated with a reduced amount of crestal bone loss in comparison to matching implant and abutment interfaces [9–11, 19, 20]. Several studies have noticed a lesser amount of marginal bone resorption associated with platform switched implants, including a recent systematic review and meta-analysis which states that platform switching can be considered a desirable morphologic feature that may prevent the horizontal saucerization and preserve the vertical crestal bone levels [2]. A prospective case series by Buser et al. [21], demonstrated much lesser marginal bone loss in single crowns in esthetic zones when bone level implant system with horizontal offset was used as early implant placement. Other clinical studies too support these findings [22, 23].

As the concept is not fully understood, there are different theories that try and explain reduced crestal bone loss in (platform switched) horizontally offset implants. The different theories are based on various factors like less stress distribution on the crestal bone [24, 25]; increasing the distance of the inflammatory infiltrate to crestal bone [11, 26, 27] and medializing the location of biologic width [19].

Table 6 Correlation between average initial implant depth and marginal bone loss (number of implants)

Follow-up groups	BL p value	TE p value
6–12	<0.0001 (77)*	0.977 (79)
13–24	<0.0001 (132)*	<0.0001 (89)*
25–36	<0.0001 (56)*	0.436 (43)
37–48	0.814 (15)	0.751 (41)

Analysis of our results also showed that the depth of implant placement (within the range of IDIP of our study) had a positive correlation to the amount of marginal bone loss, with deeper placed implants having slightly more bone loss than higher placed implants, when the abutment junction in BL-level implants or the rough-machined border in TE Implants is positioned below the bone level. This correlation could only be seen up to time period of 36 months (the period of the study), which clearly shows that careful longer follow-up studies would be needed. It could be opined from these findings that the marginal bony remodeling is dependent on the depth of implant placement as also noted by previous studies [7].

The initial depth of implant placement has very important clinical implications in terms of esthetics [28]. Implant placement at deeper positions for esthetic improvements would allow the use of healing caps with an emergence profile and the substitution of the prosthetic component in case of marginal tissue recession, would contribute to the maintenance of the peri-implant mucosa texture and tonality and would provide the reestablishment of the marginal tissue architecture [29, 30].

However, the marginal bone changes in relation to different vertical positions of implants have been variably reported with certain authors demonstrating greater bone loss in sub-crestal placement and certain others reporting lesser bone loss in sub-crestal positions.

Hermann and colleagues showed that when the IAJ was positioned above the crest, there was significantly less bone resorption than when it was positioned below the crest. It was also shown that the final distance of the crestal bone from the IAJ never exceeded 2 mm [4–6, 31]. Some studies [32] demonstrated that moving the IAJ supra-crestally reduces peri-implant bone loss as greater amount of inflammatory cells were seen in cases of sub-crestal implant placement. However, these studies were done on implants with matching platforms.

A more apical position of the micro-gap at the IAJ is said to be predisposed to a more anaerobic environment which could favor a more pathogenic bacterial composition that could lead to an increased amount of peri-implant inflammation [33, 34], although this exact relationship is still unclear [20].

Contradictorily, several studies have shown lesser amounts of bone resorption around implants that have been inserted much deeper. Weng et al. [12] noted (in histologic, experimental studies in dogs) lesser marginal bone loss if the implants are placed 1.5 mm sub-crestally instead of equi-crestally, with bone growth onto the implant shoulder in cases of subcrestal placement. Moreover, several histological studies have shown mineralized tissue deposits at the interface and on top of the implant surface in subcrestally placed implants that have been loaded immediately [13–15]. The studies that showed lesser bone loss at deeper initial implant depths used two-piece implants with horizontally offset abutments when the IDIP were deeper than 1.5 mm below crestal bone level.

In our retrospective analysis, among the BL implants, the deepest implant had been placed only 0.710 mm below crestal bone margin. This may be the reason why there was more bone loss with increasing depth of placement.

A major drawback of this study was in its retrospective study design, as a result of which, the implants were not placed in a randomized manner. Another drawback was that actual clinical examinations of the patients were not performed, and inclusion criteria like 'sound periodonal status' and 'adequate width of attached gingiva' were extracted from patient records. Although the radiographic method of measurement of MBL changes from orthopantamograms that has been followed in this study is an accepted method, the data is not as accurate as measurements from standardized periapical radiographs. All the implants/subjects included in the study were not examined at every follow-up time, which is another limitation. Consequentially, the respective subjects/implants represented in each time periods were necessarily not the same and the follow-up time periods were not taken at a given point of time, but were grouped over a 1-year period. No sub group analysis was done based on the type of prosthetic rehabilitation and hence this variation was not considered on the marginal bone loss of the implants.

In spite of these drawbacks, however, within the limitations of this study design, one can conclude that both the implant systems had comparable minimal bone loss up to 36 months with BL having statistically significant lesser bone loss as compared to the TE (although the difference may not be clinically significant). Both implant concepts show high clinical success with stable marginal bone levels: either with the abutment connection away from the bone in the tissue level, or a horizontally offset abutment connection at bone level. So the choice between these implant designs should be dependent on other clinical demands such as aesthetics, crown length, emergence profile, etc. The initial depth of implant placement had an influence on the amount of marginal bone loss, with deeper placed implants having more marginal bone loss in periods up to 3 years.

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Conflict of interest The senior authors Prof Wagner und Prof Al-Nawas declare that they were involved in education and scientific lectures and get research grants by the Straumann company but have no conflicts of interest in this study. All other authors have no conflict of interest in the study.

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