Long-Term Results after Subcrestal or Crestal Placement of Delayed Loaded Implants

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ABSTRACT

Purpose: Prevention of peri-implant bone loss is essential for achieving long-term implant success, but few studies have evaluated the impact of placement depth on long-term bone loss. The aim of this retrospective study was to evaluate outcomes for platform-shifted implants placed at different depths relative to the bone crest.

Materials and Methods: The mesial and distal shoulders of 228 delayed-loaded Ankylos® (Dentsply Implants Manufacturing GmbH, Mannheim, Germany) implants placed in 85 patients were divided retrospectively into two groups based on the implant shoulder position on the day of placement surgery as follows: subcrestal group A ($n = 197$; 0.5 mm or more below the crestal bone level) or crestal group B ($n = 65$; within 0.5 mm or less of the crestal bone level). The remaining sites ($n = 194$; more than 0.5 mm above the crestal bone level) were supracrestal and were excluded from this analysis. Mesial and distal bone loss was evaluated under 5× magnification and analyzed, along with Periotest values.

Results: Mean Periotest values were −1.77 (±3.57) for Group A and −1.77 (±3.26) for Group B. For Group A, mean mesial (m) bone loss was 1.84 (±1.49 mm) and mean distal (d) bone loss was 1.73 (±1.31 mm). For Group B, the bone loss values were m: 1.41 (±1.65 mm) and d: 1.34 (±1.60 mm). No statistically significant differences were found for the Periotest values ($p = .521$) or bone level values for the two groups (m: $p = .130$; d: $p = .153$).

Conclusion: Within the limitations of this study, subcrestal or crestal implant placement in combination with delayed loading was associated with similar initial implant stability and subsequent crestal bone loss.

KEY WORDS: crestal, implant position, subcrestal

INTRODUCTION

Limiting the extent of peri-implant bone loss has been recognized for decades to be an important aspect of long-term implant success,[1–3] and stable peri-implant bone conditions play an important role in maintaining esthetics. However, the etiology of peri-implant bone loss is still being discussed and evaluated.[4] Among factors affecting marginal bone stability are the periodontal biotype,[5,6] bone density, formation of the biologic width,[7] interimplant distance,[8] surgical trauma,[9–11] implant micro- and macrodesign,[12] location of the implant-abutment interface,[4] peri-implantitis,[13] occlusal trauma, and stress concentration at the crestal bone level.[14]

To date, the opinion expressed widely in the scientific literature has been that subcrestal implant placement leads to increased crestal bone resorption. However, clinical studies addressing the implant-placement depth in relation to crestal bone have been rare. Data on subcrestal versus crestal placement have mostly come from animal studies.[7,15–17] Even fewer data are available regarding the effects of crestal versus subcrestal positioning of platform-switched implants.

The purpose of the present study was to clinically and radiologically evaluate retrospectively crestal bone loss around delayed-loaded platform-switched implants

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placed in one of two different positions (crestal and subcrestal) relative to the bone crests.

MATERIALS AND METHODS

Patients at the Department of Oral Surgery and Implant Dentistry, Dental School Frankfurt, Germany, who had required implant therapy for prosthetic rehabilitation with a fixed or removable prosthesis, were identified. All patients had to have had implants placed by the same oral surgeon (GER) between 1993 and 2004 and restored by dentists trained with the ANKYLOS® Implant System (Dentsply Implants Manufacturing GmbH, Mannheim, Germany). The body of this implant is slightly tapered, with a sandblasted, acid-etched surface, a 2 mm machined collar, and a progressive thread design.

Inclusion criteria were subcrestal implant placement (with the mesial and/or distal shoulder at least 0.5 mm below the crestal bone level) or crestal placement (with the mesial and/or distal shoulder placed within 0.5 mm or less of the crestal bone level) and use of a delayed loading protocol (i.e., functional loading accomplished after a submerged healing period). Exclusion criteria were supracrestal implant positioning (i.e., placement of the implant shoulder more than 0.5 mm above the crestal bone level), presence of acute infection at any time throughout the observation period, uncontrolled diabetes, and/or alcohol or drug abuse. All study patients were classified according to whether their implant shoulders were placed subcrestally (group A) or crestally (group B).

SURGICAL PROTOCOL

After preoperative clinical and radiologic evaluation, diagnosis, and treatment planning, all implant-placement surgeries were carried out under local anesthesia with articaine 4% (40 mg/mL, 1:200,000). The implant sites were following the drilling protocol recommended by the manufacturer. All implants (3.5 mm, 4.5 mm, and 5.5 mm diameter) were placed in a submerged mode, and suture removal was carried out after 7 to 10 days.

After a 3- to 6-month healing period, a minimally invasive flap was elevated to uncover the implants. Prefabricated healing abutments were inserted, and abutment-level impressions were taken using prefabricated impression caps. Final restorations were delivered and cemented with temporary cement (Temp Bond®, Kerr Corporation, Orange, CA, USA).

The standardized follow-up protocol included these measures. Immediately after implant placement, implant stability was evaluated using the Periotest S® (Gulden Medizintechnik Gulden e.k., Modautal, Germany). Periapical radiographs were taken with a Heliodent DS® (Sirona, Bensheim, Germany) using a Rinn-XCP radiographic film holder (Dentsply Rinn, Elgin, IL, USA) or panoramic radiographs (Orthophos®, Sirona, Bensheim, Germany). The radiographs were digitized with a scanner, retrospectively. Thereafter, clinical and radiographic evaluation was performed annually (Figures 1 and 2).

Implant success criteria were the absence of mobility or peri-implant radiolucency, with no signs of infection or pain.

Radiographic Examination

For the retrospective study, the status of the crestal bone was assessed using the Sidexis neXt Generation® software (Sirona). Using 5× magnification, the distance

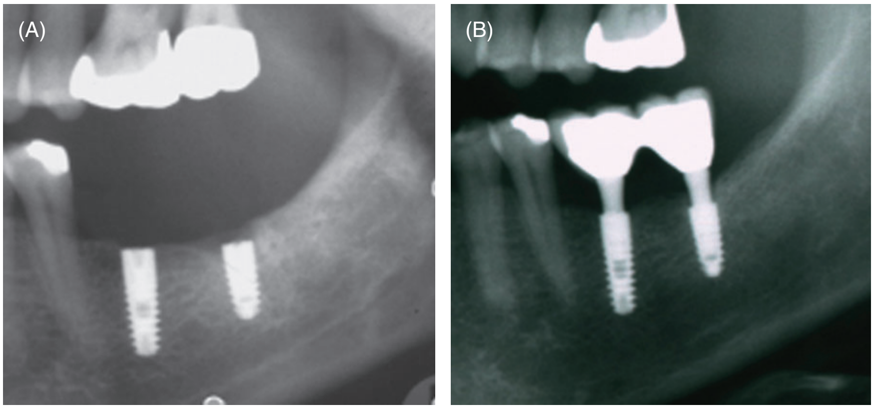

Figure 1 *A*, Radiographic evaluation after subcrestal placement of 2 implants (baseline). *B*, Radiographic evaluation after subcrestal placement of two implants (13 years follow-up) demonstrating no bone loss.

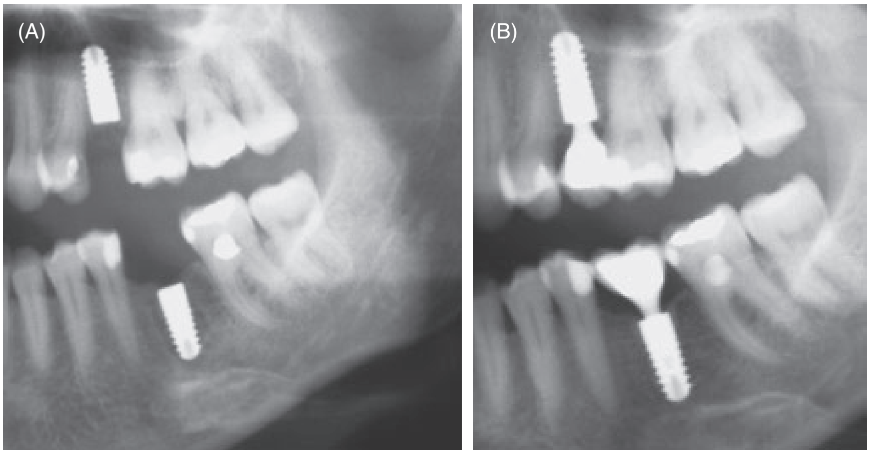

Figure 2 *A*, Radiographic evaluation after subcrestal placement of two implants in the maxilla and mandible (baseline). *B*, Radiographic evaluation after subcrestal placement of two implants (12 years follow-up) demonstrating crestal bone stability.

from the mesial and distal shoulder of each implant to the crestal bone was measured and recorded (in mm) after calibration of the resolution of the radiographs between the different examination intervals. Using this software, we were able to have an accurate assessment of the crest of bone and to analyze the bone changes over period of time. Bone loss was defined as a positive value and bone gain as a negative one. Mean values, standard deviations, and maximum and minimum values were calculated.

Statistical Analysis

Statistical analysis was accomplished using SPSS® (Statistical Package for Social Sciences Version 20.0, SPSS Inc., Chicago, IL, USA). The Kaplan–Meier method was used to compute success and survival rates.[18]

RESULTS

Eighty-five patients (41 men and 44 women) were included in the retrospective study. Their mean age was 50.51 (±13.32) years; the range was 16 to 80 years. In this retrospective clinical study, results for 228 delayed loaded implants were evaluated.

The mesial and distal shoulders of the 228 implants were categorized as follows: subcrestal group A ($n = 197$) and crestal group B ($n = 65$). The remaining sites ($n = 194$; implant shoulder more than 0.5 mm above the bone level) were supracrestal (and were excluded from this analysis).

The healing period before second-stage surgery for the implants placed completely subcrestally (both mesial and distal shoulders) was 4.21 (±2.38) months for the subcrestal group (A). It was 4.20 (±2.07) months for the crestal group (mesial and distal) (B). The mean observation period was 105.61 (±49.74) months for group A (subcrestal) and 94.10 (±52.42) months for group B (crestal). The mean loading period was 101.39 (±49.77) months for group A (subcrestal) and 89.90 (±52.37) months for group B (crestal); the mean observation period for all implants was 91.83 (±52.85) months. Of the 228 total implants, five implants (2.19%) were lost, resulting to a cumulative survival rate of 97.8% (Figure 3) and a cumulative success rate of 94.7%.

Descriptive data about the five failed implants are presented in Table 1. Failures were due to a lack of osseointegration ($n = 1$) and peri-implantitis ($n = 4$). The periods for implant failures were 4 months (1 implant), 6 months (2 implants), 79 months (1 implant), and 162 months (1 implant). Thus, one failure occurred during the healing phase, while the other four failures occurred during the loading period. Three of the failed implants (60%) were in the posterior maxilla, while two failures (40%) occurred in the

TABLE 1 Characteristics of the Failed Implants according to Their Location and Placement Level

Implant	Location	Placement Level (Mesial/Distal in mm)
1: 3.5/11 mm	#4:	−1.76 m / 1.61 d
2: 4.5/9.5 mm	#4:	0.48 m / −0.13 d
3: 4.5/9.5 mm	#13:	−1.33 m / −0.80 d
4: 4.5/9.5 mm	#26:	−0.18 m / −0.90 d
5: 4.5/8 mm	#30:	−1.00 m / −1.30 d

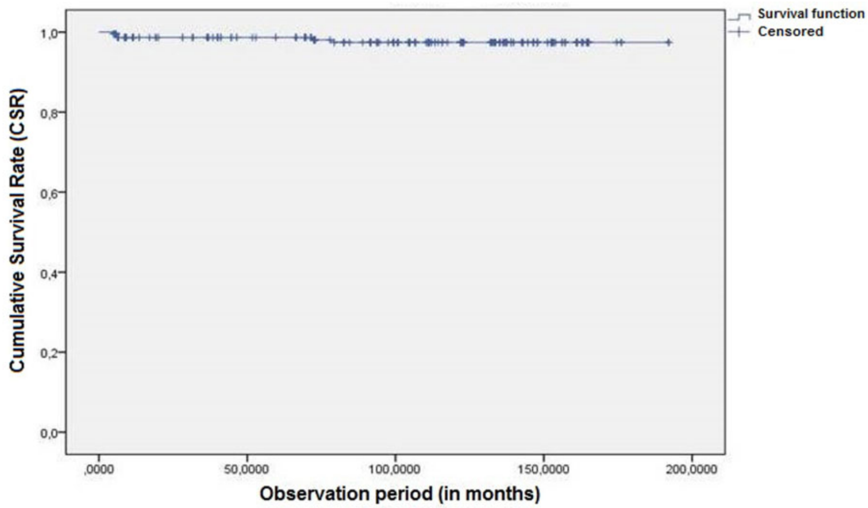

Figure 3 Kaplan–Meier analysis representing the high survival rates in subcrestal and crestal implant placements.

mandible. Two of the implant failures occurred in one patient who had diabetes, one failure occurred in a patient who was osteoporotic and a smoker, and two failures were associated with unremarkable medical histories.

Radiographically, a mean bone loss of 1.84 (±1.49 mm) mesial and 1.73 (±1.31 mm) distal was found for group A. For group B, the mean bone loss was 1.41 (±1.65 mm) mesial and 1.34 (±1.60 mm) distal. Statistical comparison showed no significant difference between the bone level values ($p > .05$) (Figures 4A–C). The difference between the average Periotest values for the subcrestal group (1.93 ± 3.58) and crestal group (−1.79 ± 3.25) was also not statistically significant ($p > .05$) (Figure 5). The changes (loss vs gain) of the bone levels (in mm) for subcrestal and crestal placed implants in conjunction with the loading period (in months) were presented in Table 2.

DISCUSSION

Maintenance of peri-implant bone levels is an important factor in the long-term prognosis and success of implants. In most studies, marginal bone level changes have been documented to occur in the first year after prosthetic loading; afterwards, the levels stabilize and eventually reach a steady state.[7,19] More than 20 years ago, peri-implant bone loss of no more than 1 to 1.5 mm in the first year after functional loading and ≤0.2 mm per year in following years was established as compatible with long-term implant success.[1,2,20]

Factors associated with marginal bone loss include surgically induced trauma,[21,22] the formation of the biologic width,[7] and frequent removal and reconnection of prosthetic components.[23] In a randomized clinical trial, Canullo and colleagues[24] evaluated the influence on marginal bone loss of using immediately definitive abutments (the one abutment–one time concept) versus provisional abutments that are disconnected, reconnected, and later replaced by definitive abutments. The authors concluded that the one abutment–one time concept might be a potential additional strategy to further decrease peri-implant crestal bone resorption. Cochran and colleagues[25] reported that most marginal bone-level changes take place between implant placement and final restoration and result from prosthetic manipulations and apical migration of the biologic width. Avoidance of abutment removal in order to maintain marginal bone stability has been documented for many years using various treatment protocols.[26]

The concept of platform switching, that is, connecting wider-diameter dental implants to standard-diameter restorative components, was described by Lazzara and Porter[27] as a means of preserving marginal bone. Platform switching alters the relationship between the implant-abutment interface (the microgap) and the bone crest. It shifts the inflammatory cell infiltrate around the microgap inward, increasing the distance between it and the alveolar crest and thus lessening its bone-resorptive effects.[12,28–30] The tapered connection eliminates micromovements between the implant and abutment.[31–33] Peri-implant bone preservation may become more obvious as the difference in diameter between the implant and suprastructure gets bigger.[4,19,34–37] The effect of bone preservation as a result

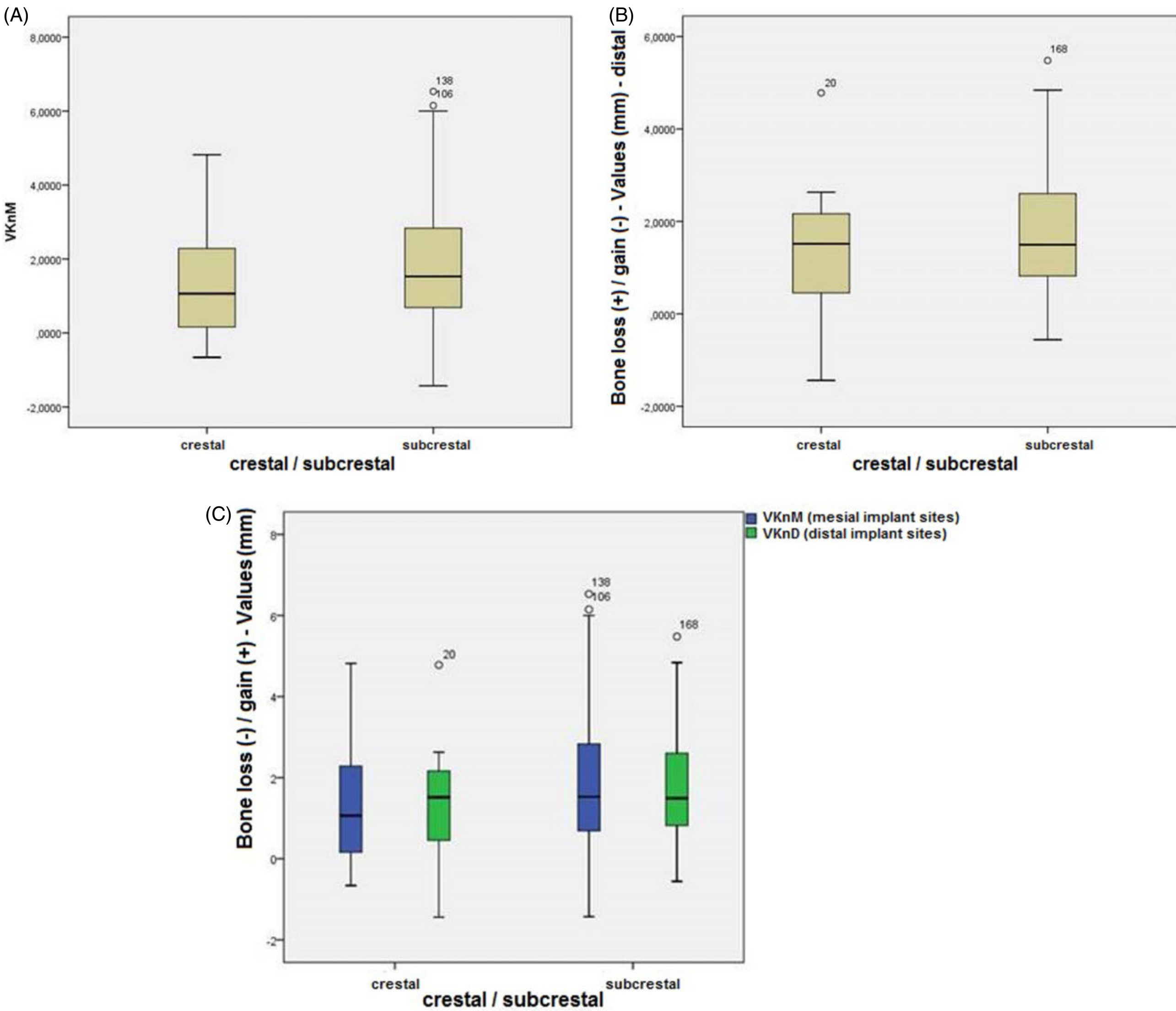

Figure 4 *A*, Bone levels at the mesial sites for crestal versus subcrestal placement. *B*, Bone levels at the distal sites for crestal versus subcrestal placement. *C*, Bone levels (with bone loss represented as a positive value) at distal (green) and mesial (blue) sites on crestal versus subcrestal placement.

of platform switching has been shown in various case reports,[27,38,39] case-controlled studies,[40–42] and randomized controlled clinical trials.[43–46]

The design of the implant system used in the present study incorporates platform shifting as well as a tapered connection that prevents micromovements and discourages out-migration of bacteria from the implant-abutment junction. This has been shown to have a positive effect on peri-implant bone preservation.[17] This may be a characteristic finding associated with the special shoulder design of the Ankylos dental implant system and it cannot be possibly generalized with other implant systems.

Combining these design elements with subcrestal implant positioning has been suggested as a way to maintain and reposition peri-implant soft[7,27] and hard tissue.[17] However, few studies previously have analyzed the influence on peri-implant hard and soft tissue of the implant position corono-apically. Most of the relevant literature has consisted of animal studies.[7,15,16,47]

In the present study, the values found for marginal bone loss around implants placed both crestally and subcrestally were comparable and similar with those reported previously in the literature. It seems evident, however, that implant placement at the bone level may be associated with a higher risk of implant exposure

TABLE 2 Alterations (Loss vs Gain) of the Bone Levels (in mm) for Subcrestal and Crestal Placed Implants in Conjunction with the Loading Period (in Months)

	Bone Loss (+) and Bone Gain (–) (mm)	Loading (Months) Mean	SD	Median	Maximum	Minimum	*n*
Group A (subcrestal)							
VKn (mesial)							
(–)	1	98.90	—	—	—	—	1
(–)	0–1	112.28	47.98	121.75	158.83	5.10	8
(+)	0–1	92.01	48.22	98.90	163.47	1.87	45
(+)	1	93.63	50.16	98.90	163.47	3.77	45
(+)	2	122.07	42.21	135.87	188.07	4.50	40
(+)	3	80.75	60.29	100.40	100.40	2.17	19
(+)	4	36.51	20.51	33.93	69.87	4.63	10
(+)	5	76.33	—	—	76.33	76.33	1
(+)	6	91.27	4.61	91.40	96.37	85.90	4
VKn (distal)							
(–)	0–1	108.76	53.15	131.37	159.37	5.10	13
(+)	0–1	90.34	45.89	98.90	158.87	1.87	39
(+)	1	96.73	50.31	111.10	163.47	3.77	49
(+)	2	119.41	47.10	138.25	188.07	4.50	26
(+)	3	123.76	34.06	129.50	188.07	66.30	19
(+)	4	86.44	0.24	88.37	144.83	2.17	6
(+)	5	129.50	—	—	129.50	129.50	1
Group B (crestal)							
VKn (mesial)							
(–)	0–1	77.52	49.64	92.65	131.37	6.50	6
(+)	0–1	102.65	42.95	102.50	163.07	4.50	12
(+)	1	87.88	55.45	100.67	157.13	3.77	14
(+)	2	64.37	52.02	66.30	135.87	0.20	5
(+)	3	93.80	47.80	97.80	147.17	32.43	4
(+)	4	4.82	—	—	4.82	4.82	1
VKn (distal)							
(–)	1	6.50	—	—	6.50	6.50	1
(–)	0–1	98.63	51.02	106.10	154.17	6.50	6
(+)	0–1	97.97	41.71	102.43	163.07	4.50	11
(+)	1	91.52	62.85	120.58	157.13	3.77	10
(+)	2	75.19	51.62	87.57	135.87	0.20	6
(+)	3	—	—	—	—	—	0
(+)	4	32.43	—	—	32.43	32.43	1

Vkn, vertical bone change.

because, according to Albrektsson and colleagues,[2] 0.1 to 0.2 mm per year of crestal bone loss after loading can be considered as normal and successful. Placing the implant subcrestally minimizes that risk, and subcrestal placement of platform-switched implants enables bone stability or growth over the implant shoulder. Platform switching also makes it possible to connect prosthetic components to subcrestally placed implants without completely removing the bone covering the margin of the implant platform. Subcrestal implant placement also can avoid the necessity of augmentation procedures in certain cases, as the apical part of the alveolar ridge is

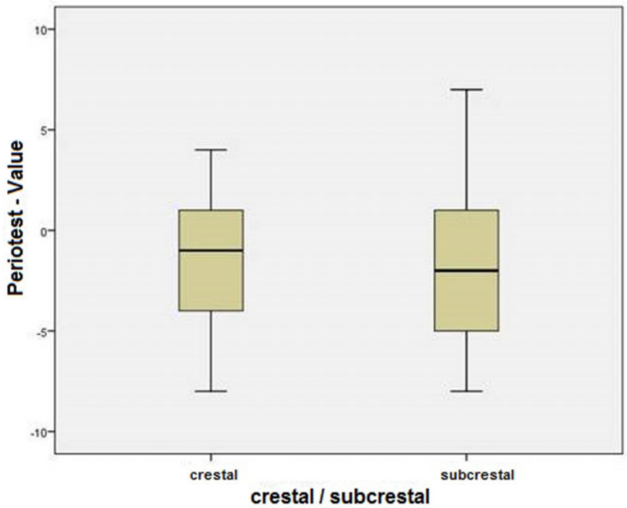

Figure 5 Periotest values for implants with crestal versus subcrestal placement.

commonly wider than the coronal part of the alveolar ridge.

Five implants were lost throughout the observation period due to insufficient integration, and peri-implantitis, a failure rate consistent with implant success, as established in the literature.[48] The reason for implant loss can be insufficient quality or quantity of peri-implant hard and soft tissue, medical status of patient, unfavorable habits, inadequate surgical and prosthetic treatment, implant design, implant localization and position, and *last but not least*, insufficient plaque control leading to peri-implantitis and implant failure.[21,49–51]

CONCLUSIONS

This retrospective study of platform-switched implants placed using a submerged (delayed loading) protocol investigated whether the implants' corono-apical position (with placement either at the crest or below it) affected long-term crestal bone loss.

Within the study limitations (using platform-shifted implants and not removing the prosthetic components), bone loss patterns within both groups appeared to be minimal. Further long-term studies are necessary to verify and detail the presented results.

CONFLICT OF INTEREST

The authors declare no conflicts of interest with respect to the authorship and/or publication of this article.

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