Original Article

A retrospective study of crestal bone changes at fixture-abutment junctions for implants with horizontal offsets

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Abstract

Purpose: *The esthetics and longevity of dental implant-supported prostheses depend on the successful integration of peri-implant soft and hard tissues , with the phenomenon of early bone resorption up to 1.5 mm being a key factor for success. The purpose of this study was to track the effect of horizontal platform switching (PS) that hides microgaps in the height of the alveolar bone around the implant .*

Materials and methods: *Periapical radiographs of 54 implants in the control group and 41 implants in the PS group were collected. These radiographs were digitized to measure the amount of peri-implant crestal bone resorption. Such data was recorded every 3 months between the baseline (2nd stage surgery) and 12-month follow-up and every 12 months after the 1st year of loading. The amounts of bone loss in both groups were compared using the Student t-test.*

Results: *There was no significant difference in crestal bone loss between the control group and the PS group except at the 36-month follow-up (P<0.03). The mean crestal bone loss was 1.20±0.67 mm in the control group and 1.18±0.59 mm in the PS group at 12 months. The annual bone loss after the 1st year in the control group and the PS group was 0.12±0.3 mm and 0.08±0.35 mm, respectively.*

Conclusion: *The amount of early peri-implant bone resorption and annual bone loss after the first year of loading in this study was comparable with the amounts reported in the literature. The results indicating no significant difference in crestal bone loss between the two groups may have been due to when the PS was performed. The smaller diameter abutments were connected to implant fixtures when the prostheses were delivered, rather than at the time of the surgical exposure of the implants. As for the effect of horizontal offsets on late implant bone loss, studies with larger sample sizes should be conducted. The results of this study indicated no significant difference in the amounts of crestal bone loss between the control group and the PS group except at the 36-month follow-up. These results suggest that a further study with a larger sample size and PS performed before the 2nd stage surgery should be conducted to clarify the effect of PS .*

Key words: Dental implants; Bone loss; wide-diameter dental implants; microgap; platform switching

Introduction

Since osseointegration was discovered and defined in the 1960s by Dr. Brånemark and his colleagues[1,2,3], dental implants have become a reliable treatment option in contemporary dentistry. Dental implants have been proven to have a high success rate[4,5], with long-term success rates of up to 92%[6] for more than 15 years of service. Among the criteria for evaluating the success of implants[7,8], the amount of alveolar bone resorption around the implants is a key factor. The crestal bone resorption in the vertical direction is about 0.9-1.6 mm in two-piece submerged implants in the first year after healing abutments or prosthetic abutments are attached. The annual alveolar bone resorption then decreases to 0.05-0.13 mm[9,10] after the first year of service of implants. The phenomenon of larger bone resorption in the first year of loading is called early bone loss. The smaller amount of peri-implant bone loss afterward is called late bone loss[4,5]. From the late 1980s, wide-diameter (5 ~ 6 mm) implants were used to increase the contact area between the bone and implant. The resulting average amount of alveolar bone loss around an implant was reported to be 0.9 ~ 1.4 mm after short-term follow-up[11,12].

Factors possibly affecting peri-implant crestal bone loss include the establishment of biologic width[13,14,15,16,17], the occlusal overload[18,19,20], the microgap[21,22,23,24], and the crest module[25,26]. Lazarra[27] proposed the use of platform switching (PS) to diminish the adverse effect of microgaps by connecting small-diameter abutments to large-diameter implant fixtures. He found less early peri-implant crestal bone loss in implants with PS.

The purpose of this study was to compare the amounts of crestal bone resorption for wide-diameter implants with PS (the PS group) and without PS (the control group). The hypothesis of this study was that the use of PS with externally hexed implants could reduce peri-implant crestal bone loss.

Materials and methods

I. Data screening and collection

The flow chart of this research is shown in Figure 1a. All samples were collected from patients treated with implant restoration following standard surgery, prosthetic, and recall protocols at least 1 year after the 2nd stage surgery in the Department of Dentistry of China Medical University Hospital between 1998 and 2005. All of the patients signed informed consent forms before undergoing implant placement. The implants placed were all large-diameter implants of the Osseotite Parallel Walled system (Biomet 3i, Palm Beach Gardens, Florida). The implant fixtures were placed equicrestally. Healing abutments with the same diameter as the implant fixtures were then attached in the 2nd stage surgery. Implants with prosthetic abutments of the same size as the implant fixtures were used for the control group, while implants with prosthetic abutments 1 mm smaller than the diameter of the implant fixtures were used for the PS group, as shown in Figure 1b. The beam-guiding film holder (XCP® Instrument Kit, Dentsply) was used when taking periapical radiographs of these implants. The inclusion criterion for the radiographs was that they consist of clear images of externally hexed large-diameter implants. If the image quality of a radiograph was such that the highest point of the bone-implant contact area could not be determined, then that radiograph was excluded from the data collection.

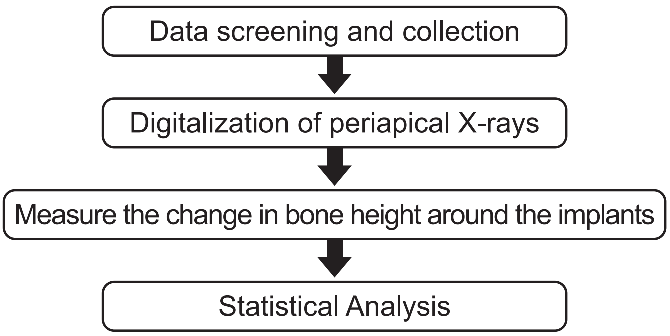

Figure 1a. Theflow chart of this research.

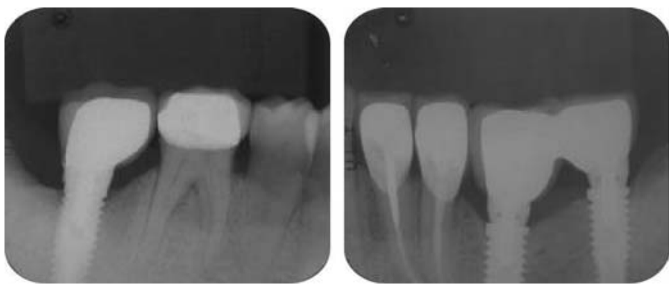

Figure 1b. Periapical radiographs of research subjects.
(a) Control group - left, (b) PS group - right.

II. Digitization of radiographic images

The periapical radiographs of all samples meeting the inclusion criterion were collected. Digitization with a 16-bit grayscale and 720 dpi resolution mode was performed with a scanner (Epson Perfection 4990 PHOTO, Seiko Epson Corporation, Nagano, Japan).

III. Measurement of the height of the alveolar bone around the implant

The bone height on the mesial and distal sides of each implant was recorded every 3 months between the baseline (2nd stage surgery) and the 12-month follow-up and then every 12 months after the 1st year of loading. AutoCAD software (Autodesk, Inc., San Rafael, California) was utilized for the measurement of the bone height. Bone height is defined as the length between the top of the implant fixture (i.e., the original point) and the highest point of the crestal bone. The calculation of actual bone height is shown in Figure 2. A negative value for bone height indicates bone loss, and a positive value indicates bone gain. The crestal bone change was obtained by subtracting the value of the bone height recorded at a given follow-up time point from that at baseline.

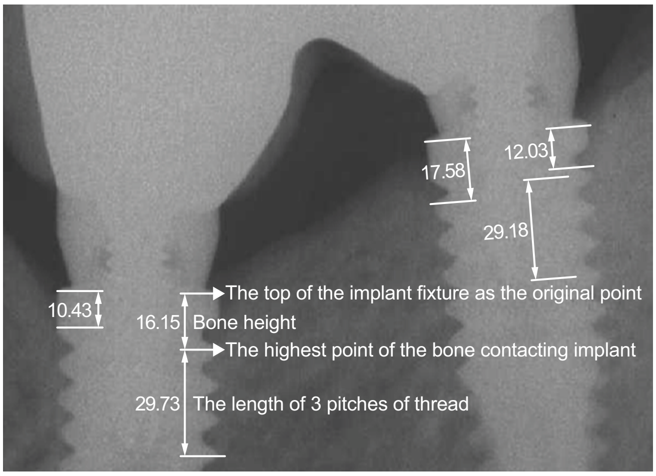

Figure 2. Measurement of bone height around the implant. Taking the 36 distal side as an example, the bone height measured by the software was -16.15, and the length of 3 pitches of threads used for calibration measured by the software was 29.73. In fact, the length of 3 pitches of threads is 2.7 mm, so the real bone height is: -16.15/29.73 x 2.7 =-1.47 mm (rounded to the second decimal place).

The bone height on the mesial side and the distal side were recorded respectively. A specification of the implant fixture (i.e., the actual length of 3 pitches of threads was 2.7 mm) was used for calibration of the measurement.

IV.Statistical Analysis

The Student *t* test was used to compare the data of the PS group and the control group. The paired t test was used to compare the bone height data for the mesial and the distal sides within both groups.

Results

I. Implant distribution

The distribution of the implants is listed in Table 1. There were 34 patients with 54 implants in the control group and 24 patients with 41 implants in the PS group. For all subjects, same sized healing abutments were connected to the implant fixtures in the 2nd stage surgery. The average time period for restoration connection was 2.4±1.2 months after the 2nd stage surgery in the control group and 2.7±2.4 months in the PS group. The average follow-up period for the implants was 26.6±13.6 months, with a range of 10.5 months to 67 months.

Table 1. Distribution of the implants

	Neck designs		
	Control	Platform switching	Total
Diameter			
5 mm	47	34	81
6 mm	7	7	14
Length			
10 mm	7	11	18
11 mm	34	19	53
13 mm	12	10	22
15 mm	1	1	2
Jaw			
Maxilla	13	8	21
Mandible	41	33	74
Site			
Canine	2	4	6
Premolar	7	3	10
Molar	45	34	79
Type of prosthesis			
FPD	43	26	69
Single	11	11	22
Removable	0	4	4
Gender			
Male	36	24	60
Female	18	17	35
Mean age	47.1 (20~67)	50.3 (30~67)	48.5

II. Results of crestal bone changes

The sizes of the samples and the amounts of crestal bone loss on the mesial side at different follow-up time points in both groups are shown in Table 2 and Figure 3. The amounts of crestal bone loss on the distal side are shown in Table 3 and Figure 4. The average amounts of crestal bone loss on both the mesial and distal sides are shown in Table 4 and Figure 5.

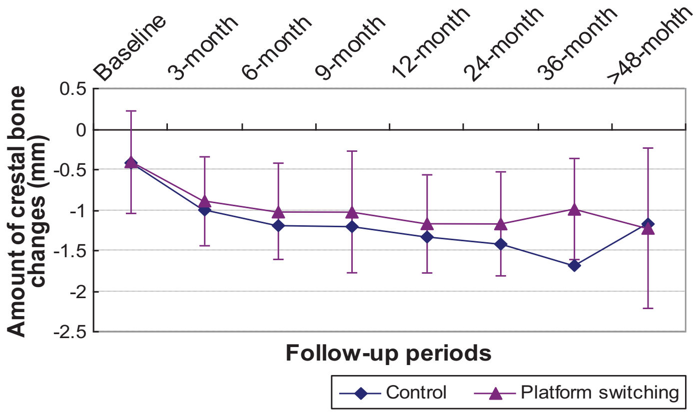

Figure 3. Crestal bone changes from baseline--mesial side.

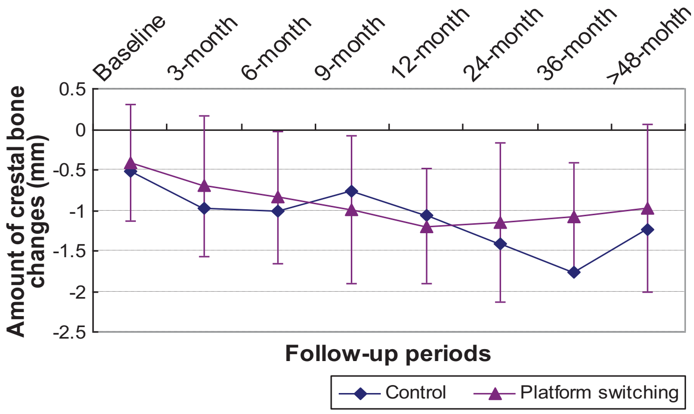

Figure 4. Crestal bone changes from baseline--distal side.

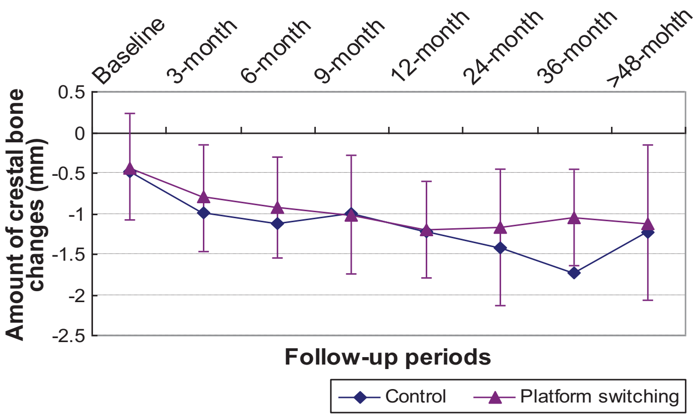

Figure 5. Crestal bone changes from baseline.

Table 2. Crestal bone changes from baseline -- mesial side

	Neck designs					
	Control			Platform switching		
Follow-up	n	Mean (mm)	SD	n	Mean (mm)	SD
Baseline	54	-0.42	0.69	41	-0.40	0.63
3-month	44	-1.02	0.57	37	-0.89	0.55
6-month	17	-1.19	0.96	19	-1.01	0.60
9-month	10	-1.20	0.94	17	-1.02	0.75
12-month	34	-1.33	0.76	28	-1.16	0.60
24-month	28	-1.42	0.87	24	-1.17	0.64
36-month	10	-1.67*	0.77	7	-0.98*	0.62
>48-month	6	-1.17	0.76	7	-1.22	0.99

*$P < 0.05$

Table 3. Crestal bone changes from baseline -- distal side

	Neck designs					
	Control			Platform switching		
Follow-up	n	Mean (mm)	SD	n	Mean (mm)	SD
Baseline	54	-0.52	0.74	41	-0.42	0.72
3-month	44	-0.97	0.59	37	-0.70	0.87
6-month	17	-1.00	0.87	19	-0.84	0.82
9-month	10	-0.77	0.50	18	-0.99	0.91
12-month	34	-1.06	0.74	28	-1.20	0.71
24-month	27	-1.42	0.90	24	-1.15	0.98
36-month	10	-1.77*	0.68	7	-1.08*	0.67
>48-month	6	-1.24	1.05	7	-0.97	1.04

*$P < 0.05$

Table 4. Crestal bone changes from baseline

	Neck designs					
	Control			Platform switching		
Follow-up	n	Mean (mm)	SD	n	Mean (mm)	SD
Baseline	54	-0.47	0.67	41	-0.41	0.65
3-month	44	-0.98	0.51	37	-0.80	0.66
6-month	17	-1.10	0.84	19	-0.92	0.62
9-month	10	-0.98	0.70	18	-1.00	0.74
12-month	34	-1.20	0.67	28	-1.18	0.59
24-month	28	-1.40	0.84	24	-1.16	0.72
36-month	10	-1.72*	0.69	7	-1.03*	0.60
>48-month	6	-1.21	0.86	7	-1.1	0.96

*$P < 0.05$

Bone resorption started at the 2nd stage surgery in more than 50% of the samples. Even though bone height was supposed to be 0 (i.e., fixtures were equicrestally placed) at the 2nd stage surgery, this was not observed in more than half of the subjects. There was no statistically significant difference in peri-implant crestal bone loss between the control and the PS groups except at the 36-month follow-up visit. The bone losses on both the mesial and distal sides in the PS group were less than those in the control group at 36 months ($P<0.03$).

The annual crestal bone loss results after the 1st year of loading are shown in Table 5. Comparing the amounts of annual peri-implant bone loss on the distal and mesial sides in both groups, it can be seen that there was more bone loss on the distal side than on the mesial side in the control group ($P<0.05$). However, there was no such difference in the PS group. Comparing the annual bone loss between the control and the PS groups, it can be seen that no statistically significant difference was revealed.

Table 5. Annual crestal bone changes after the 1st year of loading

	Neck designs					
	Control			Platform switching		
Follow-up	n	Mean (mm)	SD	n	Mean (mm)	SD
Mesial	22	-0.01*	0.37	29	-0.08	0.30
Distal	21	-0.22*	0.38	29	-0.08	0.47
Ave	22	-0.12	0.30	29	-0.08	0.35

* $P < 0.05$

Discussion

Most of the clinical studies on wide diameter implants have focused on assessing the mid-term and short-term success rates of such implants, which have been reported to range from 82.0% to 97.7%[28]. The average crestal bone resorption in the first year reported in these studies was about 0.9~1.4 mm[11,12]. The average crestal bone loss around the implant measured in the present study in the first year was 1.2±0.67 mm, and the average annual bone loss was 0.12 mm. These rates were in accordance with the standards for successful implants proposed by Albrektsson et al[7].

In the literature, the reference points for bone height are generally set between the 2nd stage surgery[11, 29] and the time of prosthesis delivery[30]. In this study, the 2nd stage surgery was chosen as a baseline to include all the causes of early crestal bone loss except for the loading factor that is activated after the healing abutment is connected. Hermann et al[16]. showed that the bone height dropped sharply within the first month after the healing abutment was attached, and the bone height had stabilized in the 2nd and 3rd months, with only a small amount of bone loss. The results of this study, as depicted in Figure 3 to Figure 5, also show that the slope of the graph in the first three months is the steepest and the bone resorption rate is the highest. Therefore, to accurately measure the early bone resorption, it is reasonable to choose the bone height at the 2nd stage surgery as a baseline.

The average bone height measured at the baseline in this study was 0.4-0.5 mm subcrestally. There are two possible reasons for this. First, although surgeons try to place the top of an implant flush with the top edges of the crest, a patient's crestal bone position may be different on the mesial and distal sides, resulting in a difference on both sides. However, statistical analysis showed that there was no significant difference between the mesial and distal bone heights at the baseline in this study. Therefore, a difference in bone height caused by unevenness of the operation area should not have affected the subsequent bone resorption measurement results. The second reason for crestal bone loss seen at the baseline is surgical trauma. A study by Wilderman et al[31]. showed that after osseous surgery, which opens the periosteum, horizontal bone resorption occurs, with an absorption volume of about 0.8 mm. During the 2nd stage surgery for implants that had achieved successful osseointegration, Adell et al[32]. and Misch et al[33]. also found bone losses of approximately 0.2 and 1.3 mm respectively. However, unlike in the findings of Wilderman et al., this bone loss did not appear horizontally in all surgical areas where the periosteum was elevated, but only around the implant.

Histological research indicates that approximately 0.75 mm of inflamed connective tissue is normally found above and below the implant-abutment connection microgap, and the alveolar bone can exist 1 mm down the connective tissue with inflammatory cell infiltration[34,35]. Therefore, in order to create enough space for the soft tissue, about 1.75 mm of bone resorption has to occur. Lazarra[27] has indicated that a horizontal offset creates additional room for inflamed connective tissue and, as a result, less vertical room is needed for connective tissue, leading in turn to reduced peri-implant bone resorption. Owing to the 90-degree platform that it provides, the horizontal offset may also produce an isolating effect that allows for a higher alveolar bone position. According to Lazarra's theory, two requirements must be met for PS to be successful. The first is that regardless of whether one-stage or two-stage surgery is performed, the healing abutment must have a small diameter. The second is that the resulting platform must be large enough to accommodate connective tissue infiltrated by inflammatory cells. In this study, the abutments were converted to smaller size from prosthetic abutments connections. Bone remodeling had already started from the healing abutment connection during the 2nd stage surgery, which was performed 4-8 weeks earlier than prosthetic abutments connection; this could be the reason for the early bone resorption seen in both the control group and the PS group.

The late bone loss observed from the 12th month to the 36th month after the abutment was attached was generally found to be mimimal in the PS group. However, the bone height of the control group continued to decline until the difference between the two groups reached statistical significance at the 36th month of tracking, showing that the two groups had different performance in terms of late bone resorption.

Previous studies have showed the effects of various factors on the average annual bone loss after the first year of loading, including the surface treatment of the implant, the width of the keratinized gingiva, the type of prosthesis installed, the implant site, the implant length and diameter, the state of opposing teeth, and smoking[36,37,38]. In this study, the amount of alveolar bone loss around the implant before the 36th month of tracking showed a stable trend in both groups. However, after the 48th month, the bone height of the control group suddenly increased, showing a phenomenon of bone gain. This result may have been due to the small sample sizes. Specifically, there were only 6 and 7 cases, respectively, in the two groups. To clarify this issue, more complete mid-term and long-term follow-up data should be obtained by tracking patients for longer periods of time in the future.

Conclusion and expectations

As this study was a retrospective study, a number confounding factors (e.g., smoking habit) could not be controlled. The results of this study show that the alveolar bone resorption of implants with horizontal offsets seems to be the same as that of implants without horizontal offsets in the first year. As the time of use is increased, however, the crestal bone resorption of implants with a horizontal offsets appeared to be less than that of the control group implants after the first year and reached a statistically significant difference at the 36th month. At the 48th month, the crestal bone height of the control group suddenly increased, causing the trend to change. There was no significant difference in the overall average annual bone resorption of the two groups in the first year after the abutment was attached to the implant. Early conversion of the horizontal platform interface, extending the tracking period, and increasing the number of samples are the directions for future related research.

Acknowledgements

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