CLINICAL ORAL IMPLANTS RESEARCH

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Marginal bone response of implants with platform switching and non-platform switching abutments in posterior healed sites: a 1-year prospective study

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Key words: bone change, conical connection, implant, partial edentulism, platform switching, posterior healed site, subcrestal placement

Abstract

Objectives: This 1-year prospective study evaluated the implant success rate and marginal bone response of non-submerged implants with platform and non-platform switching abutments in posterior healed sites.

Material and methods: Nineteen patients (9 male, 10 female) with posterior partially edentulous spaces, between the ages of 23 and 76 (mean = 55.4 years), were included in this study. A total of 30 implants (15 implants restored with platform switching [PS] abutments [control] and 15 implants restored with non-platform switching [NPS] abutments [test]) were assigned between two groups using a randomization procedure. The definitive abutments with conical connections were placed at the time of surgery, and the definitive restorations were placed at 3 months. All patients were evaluated clinically and radiographically using standardized radiographs at time of implant placement (0), 3, 6 and 12 months after implant placement. Data were analyzed using Friedman test with post hoc pairwise comparisons, Mann–Whitney U-test, and Pearson's chi-square test at the significance level of $\alpha = 0.05$.

Results: At 12 months, all 30 implants remained osseointegrated corresponding to a 100% success rate. The overall mean marginal bone level change at 12 months was -0.04 ± 0.08 mm for PS group and -0.19 ± 0.16 mm for NPS group. Statistically significant difference in the marginal bone level change was observed between groups at 0 to 12 months and 3 to 12 months ($P < 0.05$).

Conclusions: This 1-year randomized control study suggests that when a conical implant–abutment connection is present, similar peri-implant tissue responses can be achieved with platform switching and non-platform switching abutments.

Peri-implant marginal bone change around dental implants is one of the frequently used criteria when evaluating implant success (Albrektsson et al. 1986; Smith & Zarb 1989). Marginal bone change around implants can be related to multiple factors (Ericsson et al. 1995; Abrahamsson et al. 1996; Berglundh & Lindhe 1996; Hermann et al. 2000; Oh et al. 2002; Broggini et al. 2003). It has been postulated that the inflammatory cell infiltrate around the microgap at the implant–abutment junction (IAJ) causes bone remodeling, forming a connective tissue barrier, which in turn protects the underlying bone (Ericsson et al. 1995; Broggini et al. 2003). Lazzara and Porter (2006) reported the concept of platform switching (PS), in which the diameter of the implant platform was larger than the corresponding abutment. It had been suggested that PS might keep the bone close to the implant platform minimizing peri-implant marginal bone loss (Lazzara & Porter 2006). The inward reposition of the IAJ may not only provide a horizontal space for the biological width, but also shift the microgap/inflammation away from the bone (Lazzara & Porter 2006). Since then, studies have shown positive but inconclusive data on the effect of PS implant–abutment connections on marginal bone change (Cappiello et al. 2008; Becker et al. 2009; Vigolo & Givani 2009; Cannullo et al. 2010; Linkevicius et al. 2010; Chung et al. 2011; Enkling et al. 2011a,b).

The purpose of this 1-year randomized control study was to compare the marginal bone level changes around non-submerged implants with PS and non-platform switching (NPS) abutments in posterior healed sites.

Materials and methods

Patient selection

This study was approved by the Institutional Review Board of Loma Linda University and was conducted in the Center for Implant Dentistry, Loma Linda University School of Dentistry. To be included in this study, the patients must: (i) be at least 18 years of age with good oral hygiene, (ii) possess one or more missing teeth in the maxillary or mandibular posterior region (excluding third molars), (iii) have adequate bone thickness to accommodate a 4.5 mm diameter implant, (iv) have the presence of opposing dentition. Those patients with: (i) implant insertion torque value of <35 Ncm, (ii) a history of alcohol or drug dependency, or any medical, physical, or psychological factor that might affect the surgical or prosthodontic treatment and required follow-up examinations, (iii) history of bruxism, (iv) history of smoking, and/or (v) head and neck radiation treatment were excluded.

A coin toss was utilized to randomize the abutment (PS or NPS) placed in the patient. If patients were receiving more than one implant, the randomization was performed in such a way that the difference in the number of abutments of each group in the patient was not more than one. For example, if a patient was receiving 5 implants, 2 abutments would belong to one group and 3 abutments would belong to another group.

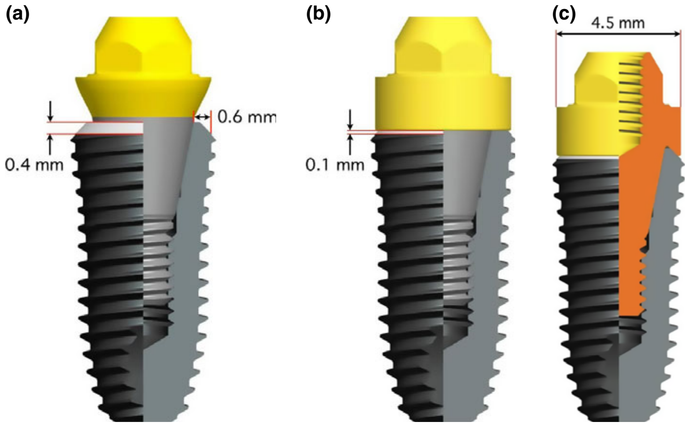

Fig. 1. Schematic drawings illustrating the implant–abutment connections. The distance between the IAJ and the RL was 0.4 mm for the PS multiple unit abutment (a) and 0.1 mm for the NPS multiple unit abutment (b and c). [Correction added on 23 January 2014, after first online publication: Figures 1(a) and (b) were published in the wrong order and have been transposed to the correct order]

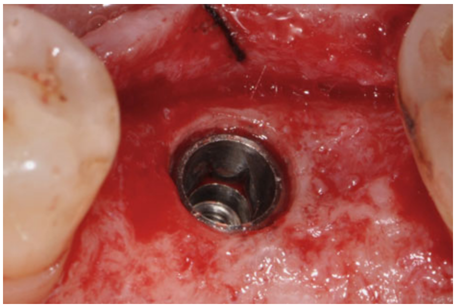

Fig. 2. The implant was placed 0.5 mm subcrestally following alveoloplasty and osteotomy.

Fig. 4. Placement of the screw-retained all ceramic crown 3 months after implant placement.

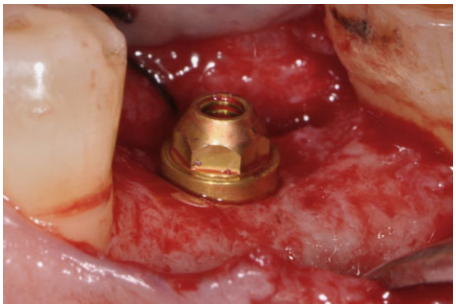

Fig. 3. Connection of the multiple unit abutment immediately after implant placement.

Clinical procedures

Following the administration of local anesthetic (2% Lidocaine with 1 : 100,000 epinephrine [Dentsply, York, PA, USA]), a full-thickness flap was reflected, and alveoloplasty was performed to level the alveolar crest prior to implant placement. The implants used in this study were 4.5 mm in diameter, threaded with SLA surface, and an internal conical connection (Superline™, DentiumUSA, Cypress, CA, USA) (Fig. 1). The implants were placed 0.5 mm subcrestally with a minimum insertion torque of 35 Ncm (Fig. 2). Resonance frequency analysis (RFA) was used to evaluate implant stability. Multiple unit abutments (either PS or NPS) were randomly selected and placed at time of surgery. The PS multiple unit abutment (Screw Abutment; Dentium Co., Ltd., Gangnam-gu, Seoul, Korea) with a horizontal mismatch of 0.6 mm was used as the control group (Fig. 1), while the NPS multiple unit abutment (Dentium Co., Ltd.) was used as the test group (Fig. 1). The abutments were torqued to 25 Ncm (Fig. 3) and plastic healing covers (Comfort Cap, Dentium Co., Ltd.) placed. Flaps were approximated to allow for non-submerged healing using an absorbable polyglactin sutures (5-0 Vicryl Plus Antibacterial suture [Ethicon; Johnson & Johnson, Somerville, NJ, USA]).

Antibiotics (Amoxicillin 500 mg [Ranbaxy Laboratories Ltd., New Delhi, India]) and analgesics (Ibuprofen 800 mg [BASF Corporation, Shreveport, LA, USA]) were prescribed post-operatively. The patients were instructed to rinse with a 0.12% chlorhexidine gluconate solution (Peridex, Zila Pharmaceuticals, Inc., Phoenix, AZ, USA) twice daily and refrain from functioning over the surgical site for the initial 3 weeks. A soft diet was recommended throughout the remaining healing period (3 months).

At 2 months, a definitive abutment level impression was made (Aquasil Monophase; Dentsply, Milford, DE, USA). At 3 months, definitive screw-retained all ceramic crown (Dentium Co., Ltd.) was connected to the multiple unit abutment with a torque of 10 Ncm (manufacturer's recommendation) (Fig. 4).

Data collection

All examinations and data collections were performed by one examiner (Y.W.). Evaluations were made at the time of implant surgery (0) and at 3, 6, and 12 months following implant placement. The following parameters were evaluated at each follow-up appointment when applicable: implant success (Smith & Zarb 1989), marginal bone level (MBL) and marginal bone level change

(MBLC), RFA (Sennerby & Meredith 2008; Zix et al. 2008), modified Plaque Index (mPI) (Mombelli et al. 1987), and surgical/prosthetic complications.

Implant success

The implant success rates were evaluated according to the criteria proposed by Smith and Zarb (1989) where applicable.

Marginal bone level and marginal bone level change

The MBLs were measured on the mesial and distal aspects of each implant using sequential standardized periapical radiographs and the long-cone paralleling technique (Strid 1985). A customized occlusal jig was made using a polyvinyl siloxane bite registration material (Exabite; GC America Inc, Alsip, IL, USA) to standardize the angulation and position of the film. The junction between the micro-roughened surface and the machined surface was used as the reference line (RL) (Fig. 5). The distance between the RL and the most coronal bone–implant contact was measured. The value zero was designated when the MBL was at the same level or coronal to the RL and negative when the bone–implant contact was apical to the RL. The average value of the mesial and distal measurements was used to represent the MBL for each implant. The MBLs were measured at 0, 3, 6 and 12 months after implant placement (Figs 6 and 7). The MBLs and MBLCs were calculated and compared within group and between groups at designated time intervals. The intraexaminer reliability of the measurements was determined by using double assessments of MBL taken 2 months apart by one examiner and expressed as the intraclass correlation coefficient (ICC).

Resonance frequency analysis

The RFA instrument (Osstell ISQ, Gothenburg, Sweden) was used to evaluate implant stability immediately after implant placement (Sennerby & Meredith 2008; Zix et al. 2008).

Modified plaque index

Presence or absence of plaque was assessed at 6 sites (mesiolabial, labial, distolabial, mesiolingual, lingual, and distolingual) around the abutment or the definitive restoration (Mombelli et al. 1987).

Surgical and prosthetic complications

Surgical complications were recorded and included but not limited to soft tissue problems, infection, or modifications of manufacturer's recommendations for implant placement. Prosthetic complications were documented, but were not limited to screw loosening, and/or repair of definitive restoration.

Data analysis

The Friedman test with post hoc pairwise comparisons was used to compare the MBLs and MBLCs within group, while the Mann–Whitney U-test was used to assess the MBLs and MBLCs between groups. Pearson chi-square test was performed to evaluate the intragroup and intergroup differences in mPI. The level of significance was set at $\alpha = 0.05$.

Results

A total of 30 implants (15 with PS abutments and 15 with NPS abutments) randomly assigned to nine male and 10 female patients between ages of 23 and 76 (mean age 55.4 years) were included in this study (Table 1). All implants possessed a diameter of 4.5 mm, with varied length (8, 10 and 12 mm). For the PS group, 5 implants were placed in the posterior maxilla and 10 implants in the posterior mandible, while for the NPS group, 3 implants were placed in the posterior maxilla and 12 implants in the posterior mandible. After one year, all implants (30/30) were stable and none had lost osseointegration, which corresponded to an overall implant success rate of 100%.

The ICC for marginal bone level measurements was 0.99, indicating that the measurements were reliable and reproducible. At baseline, the MBLs were at or coronal to the RL for all mesial and distal sites for the PS

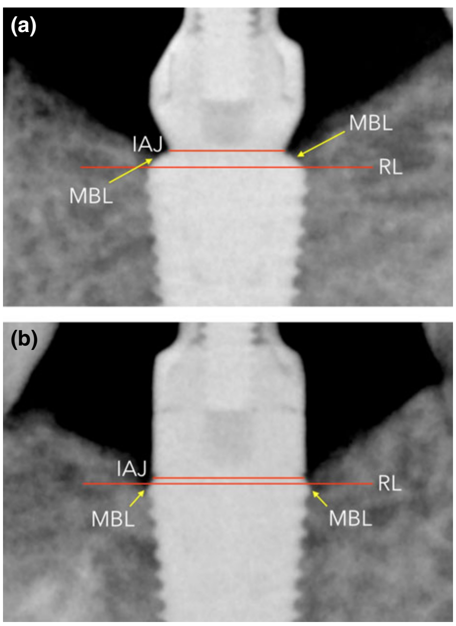

Fig. 5. Reference line (RL) used to determine marginal bone level for the PS group (a) and the NPS group (b).

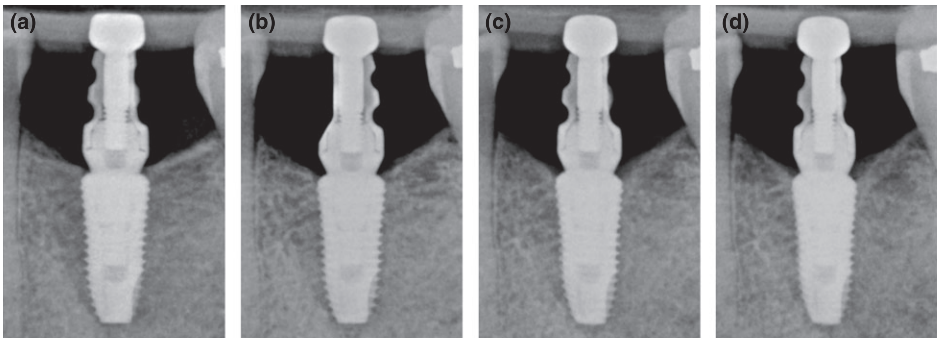

Fig. 6. Radiographs taken at the day of implant placement (0) (a), 3 months (b), 6 months (c), and 12 months (d) for the PS group.

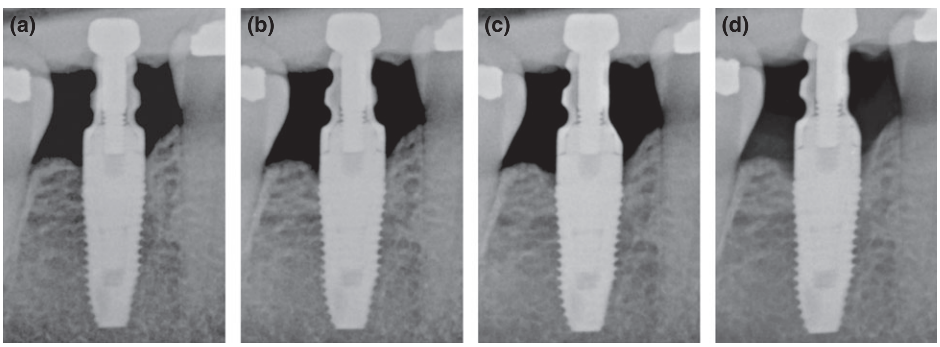

Fig. 7. Radiographs taken at the day of implant placement (0) (a), 3 months (b), 6 months (c), and 12 months (d) for the NPS group.

Table 1. **Patient distribution, locations, and implant dimensions**

Patient no.	Gender	Tooth no.	Platform type	Implant dimensions (mm)
1	M	13	PS	4.5 × 12
		14	NPS	4.5 × 12
		19	PS	4.5 × 12
		20	NPS	4.5 × 12
		28	PS	4.5 × 12
		29	NPS	4.5 × 12
		30	PS	4.5 × 12
2	M	18	PS	4.5 × 12
3	F	30	NPS	4.5 × 10
4	M	30	NPS	4.5 × 8
5	M	19	PS	4.5 × 8
6	F	14	PS	4.5 × 10
7	F	4	NPS	4.5 × 10
		13	PS	4.5 × 10
8	F	29	NPS	4.5 × 8
9	M	21	PS	4.5 × 12
		19	NPS	4.5 × 10
10	F	19	NPS	4.5 × 10
11	M	29	NPS	4.5 × 12
		30	PS	4.5 × 12
12	F	19	PS	4.5 × 10
13	M	19	NPS	4.5 × 12
14	F	30	NPS	4.5 × 12
15	F	3	PS	4.5 × 12
		2	NPS	4.5 × 12
16	M	14	PS	4.5 × 10
17	F	30	NPS	4.5 × 10
18	F	18	PS	4.5 × 10
19	M	19	PS	4.5 × 10
		30	NPS	4.5 × 12

(30/30) and NPS (30/30) group, while at 12-months, the MBLs of only 20/30 for the PS group and 15/30 for the NPS group were still found at or coronal to the RL. For statistical analysis, one implant per patient was randomly selected accounting for eight independent implants in the PS group and 11 independent implants in the NPS group (Tables 2–5). The overall MBLs at different time intervals and corresponding MBLCs for the two groups are listed in Tables 2–4. For the PS group, changes in MBLs were not statistically significant between all time periods ($P > 0.05$; Table 2). For the NPS group, significant differences were noted between all time points ($P < 0.05$) except between 0 and 3 months ($P = 0.066$), and 6 and 12 months ($P = 0.483$) (Table 3). When comparing MBLC between PS and NPS groups, statistically significant differences were noted at 0–12 months ($P = 0.041$) and 3–12 months ($P = 0.026$) (Table 4).

Table 2. **Comparison of the overall marginal bone level (MBL) and marginal bone level change (MBLC) at different time intervals for the PS group using Friedman test with post hoc pairwise comparisons at α = 0.05**

		Time interval (months)		
		3	6	12
	Mean ± SD MBL (mm)	−0.08 ± 0.19	−0.10 ± 0.17	−0.04 ± 0.08
Time interval (months)				
0	0	[−0.08 ± 0.19] {0.00} $P = 0.180$	[−0.10 ± 0.17] {0.00} $P = 0.109$	[−0.04 ± 0.08] {0.00} $P = 0.180$
3	−0.08 ± 0.19		[−0.03 ± 0.08] {0.00} $P = 0.285$	[0.04 ± 0.22] {0.00} $P = 1.0$
6	−0.10 ± 0.17			[0.07 ± 0.17] {0.00} $P = 0.109$
12	−0.04 ± 0.08			

$N = 8$.
[ ] denotes mean ± SD of marginal bone level changes between the time intervals.
{ } denotes median of marginal bone level changes between the time intervals.

The mean ISQ value at the time of implant placement was 70 (Range = 57–82). The mPI scores of 0 and 1 were consistently observed throughout the study (Table 5). No statistically significant difference was found within the group or between the two groups at the three time intervals ($P > 0.05$; Table 5).

Insertion torque of <35 Ncm was observed with 4 implants during placement, and they were not included in the study. Damage to the internal hex connection of one implant was observed during placement. The implant was removed and replaced uneventfully. The only prosthetic complication observed throughout the study was definitive prosthetic screw loosening. Prosthetic screw loosening was observed on 2 implants in two patients at 6-month follow-up and on 7 implants in four patients at 12-month follow-up. Each incidence of screw loosening was associated with a different implant for a total of 9 implants. No recurrence of prosthetic screw loosening on the same implant was noted in this study. Higher incidence of screw loosening was noted in the molar area (78% [7/9]) than the premolar area (22% [2/9]). All loose prosthetic screws were replaced and torqued to 10 Ncm (manufacturer's recommendation).

Discussion

In this study, all implants remained osseointegration at 1 year, corresponding to a 100% (30/30) implant success rate. These findings are comparable to studies with various implant systems placed at healed sites with either PS (Norton 2001; Nentwig 2004; Mangano et al. 2010; Rismanchian et al. 2011) [95.6–100%] or NPS (Naert et al. 2000; Polizzi et al. 2000; Testori et al. 2001; Griffin & Cheung 2004) [92–100%] abutments. The success rate of implants with SLA surface used in this study is also comparable to that reported for implants with similar surface (98.8–100%) (Bornstein et al. 2007; Cochran et al. 2011; Karabuda et al. 2011).

In this study, although the difference in MBLC at 12 months between the PS group (−0.04 mm) and the NPS group (−0.19 mm) was statistically significant ($P = 0.041$; Table 4), it was not clinically significant. It is interesting to note that the MBLC reported in studies using implants with PS connection (ranged from −0.11 to −1.1 mm) (Mangano

Table 3. **Comparison of the overall marginal bone level (MBL) and marginal bone level change (MBLC) at different time intervals for the NPS group using Friedman test with post hoc pairwise comparisons at α = 0.05**

		Time interval (months)		
		3	6	12
	Mean ± SD MBL (mm)	−0.05 ± 0.07	−0.17 ± 0.19	−0.19 ± 0.16
Time interval (months)				
0	0	[−0.05 ± 0.07] {0.00} *P* = 0.066	[−0.17 ± 0.19] {−0.19} *P* = 0.028*	[−0.19 ± 0.16] {−0.22} *P* = 0.012*
3	−0.05 ± 0.07		[−0.13 ± 0.17] {−0.12} *P* = 0.027*	[−0.14 ± 0.13] {−0.18} *P* = 0.012*
6	−0.17 ± 0.19			[−0.01 ± 0.17] {−0.04} *P* = 0.483
12	−0.19 ± 0.16			

N = 11.
*Statistically significant difference.
[] denotes mean ± SD of marginal bone level changes between the time intervals.
{} denotes median of marginal bone level changes between the time intervals.

Table 4. **Comparison of marginal bone level changes (MBLCs) at different time intervals between the PS and the NPS groups (0–3, 0–6, 0–12, 3–6, 3–12, 6–12 months) using Mann–Whitney U-test at α = 0.05**

	Mean ± SD of MBLC (mm)		Mean difference	Standard error difference	95% CI		*P*
	PS (*N* = 8)	NPS (*N* = 11)			Lower	Upper	
Time Interval (months)							
0–3	−0.08 ± 0.19 [0.00]	−0.05 ± 0.07 [0.00]	−0.03	0.07	−0.19	0.13	0.717
0–6	−0.10 ± 0.17 [0.00]	−0.17 ± 0.19 [−0.19]	0.07	0.08	−0.11	0.25	0.351
0–12	−0.04 ± 0.08 [0.00]	−0.19 ± 0.16 [−0.22]	0.15	0.06	0.03	0.27	0.041*
3–6	−0.03 ± 0.08 [0.00]	−0.13 ± 0.17 [−0.12]	0.10	0.06	−0.02	0.22	0.129
3–12	0.04 ± 0.22 [0.00]	−0.14 ± 0.13 [−0.18]	0.18	0.09	−0.01	0.37	0.026*
6–12	0.07 ± 0.17 [0.00]	−0.01 ± 0.17 [−0.04]	0.08	0.08	−0.09	0.25	0.062

*Statistically significant difference.
[] denotes median of marginal bone level changes between the time intervals.

Table 5. **Distribution and comparison of mPI scores at different time intervals using Pearson chi-square test at α = 0.05**

	PS (*N* = 8)				NPS (*N* = 11)				
	0	1	2	3	0	1	2	3	P^1
3 months	6	2	0	0	9	2	0	0	1.0
6 months	8	0	0	0	8	3	0	0	0.23
12 months	7	1	0	0	8	3	0	0	0.60
P^2	0.75				1.0				

P^1, comparison between groups; P^2, comparison within group.

et al. 2010; Enkling et al. 2011a,b; Norton 2006; Donovan et al. 2010; Canullo et al. 2012) was much less than those reported in studies using implants with the NPS connection (ranged from −0.7 to −1.5 mm) (Polizzi et al. 2000; Turkyilmaz et al. 2007; Schincaglia et al. 2008; Annibali et al. 2011). Studies investigating the PS implant–abutment interface have demonstrated that the greater the horizontal mismatch, the less marginal bone level changes were observed (Baffone et al. 2011, 2012). However, in this study, the similar MBLCs observed in the two groups may be in part attributed to the conical connection being used for both the PS and the NPS groups. Microbial leakage between implants and abutments has been identified as a causative factor for chronic inflammatory infiltration of the peri-implant tissues and subsequent bone loss (Quirynen et al. 1994; Steinebrunner et al. 2005). Although microgaps have been noted at the implant prosthetic platform (Jansen et al. 1997; Orsini et al. 2000; Tsuge et al. 2008), implants with an internal conical connections may provide a more superior seal (Jansen et al. 1997; Merz et al. 2000; Norton 2000; Hansson 2003), allowing less bacterial leakage (Tesmer et al. 2009; Assenza et al. 2012) and less bone loss (Bilhan et al. 2010).

The greatest amount of MBLC observed in this study was during the first 6 months for both PS and NPS groups (Tables 2 and 3). This is in accordance with studies that have shown most of the MBLCs tend to occur within 3–6 months following one-stage implant procedures (Cochran et al. 2009; Roe et al. 2010), and it had been suggested to be related to the establishment of proper physiological–biological dimension (Hartman & Cochran 2004). In fact, during 6–12 months, the PS groups in this study showed bone gain (Table 2). This can be attributed to one implant, which originally presented with distinct bone loss at 3 months, and resulted in some bone filled at 12 months. Few authors have related the peri-implant bone gain to the stimulating capacity of loaded implants in bone remodeling (Brunski 1999) and to the implant surface (Urdaneta et al. 2011; Valderrama et al. 2011).

The RFA has been shown to be effective in evaluating implant stability (Bischof et al. 2004). Study has shown that the RFA can reliably determine the implant stability with an ISQ ≥ 47 (Nedir et al. 2004). As for predicting future osseointegration, it has been noted that implants with an ISQ ≥ 49 at placement, and loaded after 3 months, showed osseointegration after 1 year of function (Nedir et al. 2004). Others have observed similar finding for successfully osseointegrated implants which had an ISQ of 41–82 at placement using one-stage technique (Guler et al. 2011). In this study, the ISQ of 57–82 recorded during surgery was within the range of aforementioned studies, and all the 30 implants maintained osseointegration after 1 year, suggesting primary stability had been achieved at the time of implant placement.

The relationship between oral hygiene and implant failure has been controversial (Berglundh et al. 1992; van Steenberghe et al. 1993); however, it is generally agreed upon that plaque accumulation can cause an inflammatory response resulting in peri-implant bone changes (Lindquist et al. 1988). The mPI scores observed throughout the course of this study were either 0 or 1 without significant differences noted between groups, implying that the patients were able to maintain a good level of oral hygiene. Therefore, the negative effect of plaque on the marginal bone levels for this study can be considered negligible.

In this study, a high incidence of prosthetic screw loosening was observed (30%). This may be partially attributed to the small prosthetic screw with a limitation of 10 Ncm maximum torque used to connect the definitive crown to the prefabricated multiple unit abutments. With a similar prosthetic design, Levine et al. (1999) also found high incidences of prosthetic screw loosening (22.2%) for single-tooth replacement. As all of the definitive crowns in this study were screw-retained, the screw loosening complications were easily resolved.

Conclusions

Platform switching and conical implant-abutment connections have both been contributory to the maintenance of the peri-implant bone. Within the limits of this 1-year prospective clinical study, the following conclusions are offered:

1. Overall cumulative implant success rate observed was 100%.
2. Mean marginal bone level change at 12 months was similar for the PS (-0.04 ± 0.08 mm) and NPS (-0.19 ± 0.16 mm) groups.
3. Evidence from this study suggests that peri-implant marginal bone level change may not be related to the platform switch feature as much as the seal at the implant–abutment interface. Nevertheless, due to the small sample size, the results should be interpreted with cautions, and long-term study with larger sample size is warranted.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. CONSORT 2010 checklist of information to include when reporting a randomized trial.