Comparison of Clinical and Radiographic Outcomes of Platform-Switched Implants with a Rough Collar and Platform-Matched Implants with a Smooth Collar: A 1-Year Randomized Clinical Trial

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Purpose: *The aim of this study was to evaluate and compare the clinical and radiographic outcomes of single implants with a platform-switched rough collar (PSRC) and a platform-matched smooth collar (PMSC).* ***Materials and Methods:*** *Twenty-six patients missing a tooth in the anterior maxilla (through the premolars) were randomly assigned to the PSRC or the PMSC group. All implants were placed in a flapless approach and restored with an early loading protocol. Clinical measurements were performed at surgery, loading, and at 3, 6, and 12 months after loading. In addition, radiographic evaluations were carried out using standardized periapical radiographs and cone beam computed tomography. Patient satisfaction surveys were completed, and microbial analysis with DNA probes was performed.* ***Results:*** *The implant survival rate was 100% for both groups. The mean marginal bone level (MBL) was significantly higher in the PSRC group compared to the PMSC group at all time points. From the 2-week postoperative visit to 1 year postloading, the mean MBL change in the PSRC group was 0.21 ± 0.56 mm and in the PMSC group it was 0.74 ± 0.47 mm. Soft tissue profiles were stable over time, with no significant differences between groups. There were no significant differences between groups in the number of microbial species seen. Patients in both groups were highly satisfied with postoperative and postprosthetic experiences.* ***Conclusion:*** *In this study, the PSRC method preserved marginal bone by a mean of 0.53 mm more than the standard PMSC protocol. Within the limitations of the present study, it can be concluded that the PSRC protocol may be beneficial in marginal bone preservation. Longitudinal studies are needed to verify the long-term effects of this approach.* Int J Oral Maxillofac Implants 2016;31:382–390. doi: 10.11607/jomi.4189

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Serving as analogs to teeth, dental implants have proven a remarkably successful treatment from both functional and esthetic points of view. Regardless of their success, nevertheless, some biologic and mechanical limitations remain, one of which is marginal bone loss. Marginal bone loss might lead to compromised function, impaired esthetics, and even implant failure. Possible contributing factors include reestablishment of the biologic width,[1] the presence of a microgap and/or micromovement between the implant platform and abutment,[2] a foreign-body reaction,[3] surgical trauma,[4] biomechanical stress,[5] and microbial infection.[6] Implants have been modified in an attempt to overcome the aforementioned factors, and one such approach is the so-called platform switching (PS) design.

The PS concept was first proposed after it was accidentally observed that implants with mismatched abutments (narrower in diameter than their respective implants) had minimal marginal bone loss.[7] This therapeutic benefit is possibly a result of confining the inflammatory infiltration zone inward from the marginal bone and providing a more favorable distribution of occlusal

forces.[1,7] Differences in the microbial composition of the peri-implant crevice in PS and platform-matching (PM) implants were also proposed as a possible cause, but preliminary data proved otherwise.[8] Short-term comparative studies and a systematic review[9] have suggested a potential benefit of PS in preserving marginal bone. A dose effect—the larger the discrepancy between implant and abutment diameter, the more bone is preserved—has also been demonstrated.[10] Nevertheless, the effect of PS on marginal bone loss is more poorly understood when it is done in combination with other procedures, such as flapless surgery and early implant loading.

Flapless surgery, as a more conservative approach to implant placement, may present some potential advantages. Clinical trials[11–13] and a systematic review[14] have shown that flapless surgery led to significantly greater papilla fill and less bone loss. Moreover, favorable patient outcomes in terms of reduction of dental anxiety and postoperative discomfort have been reported, which lead to increased patient preference and acceptance.[15] With computer-aided implant treatment planning,[16] the predictability of this blind procedure can potentially be improved by reducing surgical complications.

An early loading protocol is one way to reduce treatment time, which is always appealing to patients.[17,18] The definition of this protocol varies, but generally the time frame falls between the immediate loading/restoration and conventional loading protocols. Studies comparing different loading protocols showed a comparable implant success rate with early loading.[19,20] A systematic review[21] concluded that the amount of marginal bone loss is independent of the loading protocol, further suggesting that early loading is a viable treatment option. This review also highlighted the paucity of information regarding early loading versus other loading protocols.

Few studies have studied the clinical and radiographic outcomes of early loaded PS implants placed via a flapless approach. Therefore, the primary aim of this randomized clinical trial was to evaluate the effects of a platform-switched rough collar (PSRC) implant and a platform-matched smooth collar (PMSC) implant on marginal bone level (MBL). Surrogate aims included assessment of hard and soft tissue profiles, peri-implant crevicular microbiota, and patient-centered outcomes.

MATERIALS AND METHODS

This study was approved by the institutional review board at the University of Michigan (HUM00046428) and performed at the School of Dentistry Graduate Periodontic Clinic, Ann Arbor, Michigan. To reach a power of 0.8, 18 patients were required, assuming that the mean difference and standard deviation in marginal bone loss, the primary outcome, between the two study arms were 0.56 mm and 0.4 mm, respectively, with a *P* value = .05.

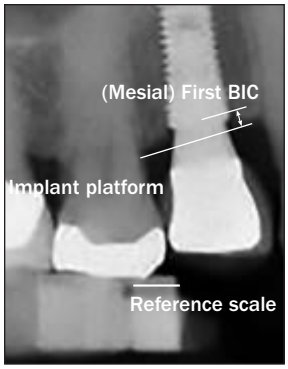
To participate in this study, patients had to: *(1)* be at least 18 years old; (*2*) be systemically healthy with no medical contraindications to implant surgery; *(3)* have a stable dental condition, eg, an intact tooth opposite the proposed implant site and good oral hygiene; and *(4)* have a single-tooth gap in the esthetic zone (in the maxillary anterior or premolar region) with minimal ridge deformities. Participants with the following conditions were excluded: *(1)* unstable medical status that may compromise wound healing; *(2)* uncontrolled bone metabolic disorders (eg, osteoporosis, Paget disease, etc); *(3)* uncontrolled dental or periodontal diseases; *(4)* deep bite, crossbite, and/or occlusal parafunction; and *(5)* an edentulous ridge with severe tissue undercut, residual root, or insufficient bone volume for a single implant, as determined on cone beam computed tomographic (CBCT) scans, or any other type of severe ridge deformity, since no grafting would be performed during flapless surgery. Moreover, patients with a hopeless tooth were not eligible for this study until the ridge was completely healed after tooth removal (at least 3 months). Participants gave written consent. Demographic information was collected from a questionnaire given to each participant. The experimental protocol was registered and can be accessed at the U.S. National Institutes of Health Clinical Trials Registry (NCT02173236).

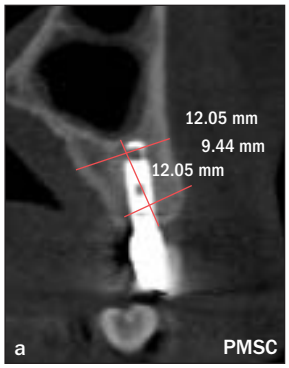
Surgical and Prosthetic Procedures

A stereolithographic model was produced from a gypsum study model and CBCT scans of each participant, from which a surgical guide was made. Immediately before implant surgery, each patient was randomly assigned to either the PSRC (test) group or the PMSC (control) group. A flapless approach was performed under local anesthesia (Xylocaine 2%/1:100,000, Dentsply Pharmaceutical). All surgeries were performed by an experienced periodontist (TJO). All PSRC implants (SuperLine, Dentium) were 3.8 mm in diameter, whereas the implants in the PMSC group (Zimmer TSV, Zimmer Dental) had diameters of 3.7 or 4.1 mm. The implant platform was placed at the facial crestal bone level, and a healing abutment of appropriate size was placed after primary stability was achieved. Soft tissue thickness and bone density were determined during surgery.

Postoperative instructions were given in both written form and verbally. The following prescriptions were given: *(1)* amoxicillin (500 mg three times daily for 10 days) or clindamycin in patients allergic to penicillin (150 mg four times daily for 10 days); *(2)* ibuprofen (600 mg every 4 to 6 hours as needed); and *(3)* antibacterial mouthwash (Peridex, 3M ESPE Dental Products; 5 to 10 mL two times daily for at least 10 days).

A postoperative visit was scheduled 10 to 14 days after implant surgery (T1). A definitive implant-supported





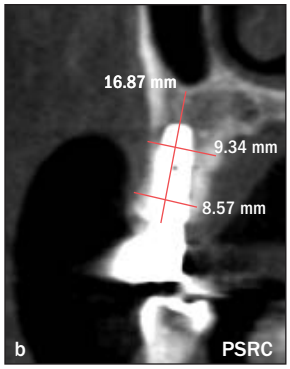


Fig 1 *(far left)* Radiographic assessments of marginal bone level (MBL) changes. MBL was defined as the vertical distance between the first radiographic bone-implant contact (BIC) and the implant platform.

Fig 2a and 2b *(left)* CBCT images with measurements at T5.

crown was delivered within 3 months postoperatively (T2) by a prosthodontist (IR) following an early loading protocol.[18]

Clinical and Radiographic Assessments

Clinical examinations were performed at T2 and again at 3 months (T3), 6 months (T4), and 12 months (T5) after definitive crown delivery by one of three calibrated examiners (YTH, ML, AC). To evaluate oral hygiene, Plaque Index (PI)[22] and Gingival Index (GI)[23] were assessed around the implant and adjacent natural teeth. Soft tissue parameters evaluated in this study comprised the Papillary Index (PPI),[24] the width of the keratinized mucosa (KMW), gingival recession (GR), and soft tissue level (STL). STL was defined as the vertical distance between the mucosal margin of the implant and the line connecting the facial gingival margin of the two adjacent teeth. Probing depth (PD) around the implant was measured at six sites (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual). All parameters were measured using a periodontal probe (UNC Probe, Hu-Friedy) to the nearest 0.5 mm.

In addition, radiographic measurements were made on periapical radiographs and CBCT scans. To avoid possible beam-hardening artifacts and scattering around dental implants, mesial and distal MBLs were evaluated via standardized periapical radiographs. Under exposure of 65 kVp and 7 mA, standardized periapical radiographs were taken using a long-cone paralleling technique and a customized indicator at T1 to T5 and subsequently digitalized at 4,800 dpi and 16-bit grayscale. MBL, defined as the vertical distance between the first radiographic bone-implant contact and the implant platform (Fig 1), were measured at each implant by a single examiner (YTH) using imaging software (ImageJ, U.S. National Institutes of Health).

Each individual underwent only two CBCT scans (3D Accuitomo 170, JMorita)—one before the final presurgical screening and the other at T5—at the Radiology Department at the University of Michigan School of Dentistry. The specifications for the radiation were 90 kV (peak) and 5 mA for 18.6 seconds with a resolution of 0.25 mm. Reconstruction and measurements of these data images were performed with a software package (Invivodent, Anatomage) on a desktop computer. Parameters evaluated from CBCT images included ridge height (RH) and ridge width at 3 mm (RW1) and 10 mm below the crest (RW2) (Fig 2). At T5, these images were also checked for the presence of perforation or dehiscence.

Microbial Analysis

Peri-implant microbial profiles were analyzed at T5. After the implant site was cleaned and isolated, five sterilized paper points were separately inserted into the sulcus at the mesiobuccal, midbuccal, distobuccal, mesiolingual, and distolingual sites of each implant. The paper points were immediately placed in a transfer tube for further DNA-based microbial analysis (Hain Diagnostics).

A total of 120 samples were evaluated, 65 from test sites and 55 from control sites, for counts of 11 different species *(Aggregatibacter actinomycetemcomitans*, *Porphyromonas gingivalis*, *Tannerella forsythia*, *Treponema denticola*, *Prevotella intermedia*, *Peptostreptococcus micros*, *Fusobacterium nucleatum/periodontium*, *Campylobacter rectus*, *Eubacterium nodatum*, *Eikenella corrodens*, and *Capnocytophaga* species*)*. The numbers of each species, except for *A actinomycetemcomitans*, were categorized into one of five levels (0 = < 10^4 cells; 1 = 10^4 to < 10^5 cells; 2 = 10^5 to < 10^6 cells; 3 = 10^6 to < 10^7 cells; and 4 = 10^7 or more cells). The cutoff points of each category for *A actinomycetemcomitans* were one log lower than the other species.

Patient Satisfaction

Patient satisfaction was assessed at T1 and T5. Within 24 hours of the postoperative experience, each participant was asked to rate the severity of pain, bleeding, swelling, and overall discomfort from 1 (not at all) to 4 (severe). At the conclusion of the study, participant satisfaction was scored with regard to comfort, function (chewing/speaking), esthetics, and overall satisfaction from 1 (excellent) to 4 (poor).

Table 1 Demographic Data of the Test and Control Groups

Demographic	PSRC (test) (n = 13)	PMSC (control) (n = 13)	Total mean	*P* value*
Age (y)	58.54 ± 14.13	56.92 ± 10.89	57.73 ± 12.64	.76
Sex				
Male	9	10	19	.66
Female	4	3	7	
Tooth location				
Anterior	3	6	9	.11
Premolar	10	7	17	
Ethnicity				
Caucasian	10	11	21	.50
African American	2	1	3	
Asian	0	1	1	
Other	1	0	1	
Smoking				
Current smoker	1	2	3	.67
Former smoker	6	4	10	
Nonsmoker	6	7	13	
Implant diameter				
3.7 mm	0	12	12	.37
3.8 mm	13	0	13	
4.1 mm	0	1	1	
Bone density				
D1	0	0	0	.56
D2	4	4	8	
D3	9	9	18	
D4	0	0	0	
Soft tissue thickness (mm)	2.11 ± 0.58	1.88 ± 0.46	2.00 ± 0.53	.27

*Student *t* test; a *P* value < .05 indicated significant differences.

Statistical Analysis

All data in this study were analyzed using statistical software (SPSS version 17.0, IBM Corporation). The statistical significance was set at .05. The *t* test and Pearson chi-square test were used to compare demographic information between groups for continuous and nominal variables, respectively. The independent Student *t* test was performed to analyze differences in clinical, radiographic, and patient-centered outcomes. Repeated-measures analysis of variance (ANOVA) was applied to examine the effects of time (within-participant factor), group (between-patient factor), and the interaction between time and group. Moreover, a linear regression model was used to evaluate the influence of two possible inherent factors—soft tissue thickness and implant diameter—on marginal bone alterations. With respect to peri-implant flora, the differences in bacterial concentrations between groups were analyzed with the Mann-Whitney *U* test.

RESULTS

Demographic Information

A total of 26 patients (7 women) with a mean age of 57.73 ± 12.64 years (range, 31 to 90 years) were recruited and treated between June 2011 and March 2014. Three patients were current smokers. No significant differences in demographic data were found between the groups. All but two participants in the PMSC group attended all visits (the two in question did not attend the T5 visit). Table 1 shows the demographics of the two groups.

Clinical and Radiographic Results

No adverse events or complications were reported during the healing period. The overall implant survival rate[25] was 100% in both groups. The results of all clinical examinations are summarized in Table 2. Oral hygiene and periodontal health were well maintained during the experimental period, with no statistically significant differences between groups or at the different time points.

Table 2 Soft Tissue Parameters and Marginal Bone Changes

	PSRC (test) (n = 13)	PMSC (control) (n = 13)	Total mean (n = 26)	*P*
Survival rate (%)	100	100	100	–
PI				
T2	0.10 ± 0.15	0.14 ± 0.21	0.12 ± 0.18	.60
T3	0.15 ± 0.29	0.09 ± 0.16	0.12 ± 0.23	.52
T4	0.07 ± 0.10	0.15 ± 0.22	0.11 ± 0.17	.20
T5	0.10 ± 0.19	0.10 ± 0.17	0.10 ± 0.18	.98
GI				
T2	0.04 ± 0.12	0.13 ± 0.25	0.08 ± 0.19	.27
T3	0.01 ± 0.03	0.06 ± 0.12	0.03 ± 0.09	.14
T4	0.03 ± 0.05	0.11 ± 0.24	0.07 ± 0.18	.22
T5	0.04 ± 0.11	0.05 ± 0.09	0.05 ± 0.10	.85
PPI				
T2	1.69 ± 0.69	1.62 ± 0.46	1.65 ± 0.58	.74
T3	1.65 ± 0.88	2.04 ± 0.56	1.85 ± 0.75	.19
T4	2.04 ± 0.83	2.00 ± 0.68	2.02 ± 0.74	.90
T5	2.19 ± 0.80	1.95 ± 0.65	2.08 ± 0.73*	.44
STL (mm)				
T2	2.32 ± 1.08	1.65 ± 0.63	1.99 ± 0.93	.07
T3	2.56 ± 1.12	1.87 ± 0.60	2.22 ± 0.95	.06
T4	2.65 ± 0.95	2.10 ± 0.88	2.38 ± 0.94	.14
T5	2.62 ± 0.88	2.08 ± 0.36	2.37 ± 0.74	.07
KMW (mm)				
T2	4.81 ± 0.67	4.60 ± 1.78	4.71 ± 1.32	.70
T3	4.73 ± 0.84	4.77 ± 2.07	4.75 ± 1.55	.95
T4	4.88 ± 0.74	4.90 ± 1.89	4.89 ± 1.41	.98
T5	4.96 ± 0.66	4.35 ± 1.93	4.68 ± 1.40	.30
PD (mm)				
T2	2.01 ± 0.35	1.96 ± 0.51	1.99 ± 0.42	.78
T3	2.55 ± 0.63	2.57 ± 0.65	2.53 ± 0.63*	.84
T4	2.81 ± 0.46	2.61 ± 0.55	2.68 ± 0.55*	.23
T5	2.82 ± 0.52	2.96 ± 0.51	2.88 ± 0.49*	.57
MBL T1 (mm)	0.22 ± 0.49	0.04 ± 0.13	0.13 ± 0.36	.21
Mean MBL change (mm)				
T1–T2	0.23 ± 0.36	0.57 ± 0.27	0.40 ± 0.36	.01†
T1–T3	0.24 ± 0.57	0.76 ± 0.40	0.50 ± 0.55	.01†
T1–T4	0.20 ± 0.50	0.76 ± 0.39	0.49 ± 0.53	.005‡
T1–T5	0.21 ± 0.56	0.74 ± 0.47	0.45 ± 0.56	.02†

*Significantly different vs crown placement (T2) (repeated-measures ANOVA; $P < .05$).
†Significantly different between groups (*t* test; $P < .05$).
‡Significantly different between groups (*t* test; $P < .01$)

PPI, STL, KMW, and PD remained stable within the experimental period in both groups (Table 2). No intergroup differences reached statistical significance in these parameters. There was a small decrease in mean KMW, from 4.71 ± 1.32 mm at T1 to 4.68 ± 1.40 mm at T5. Overall, a slight but statistically significant increase in PPI was noted over time ($P = .03$). The mean PPI values were 1.65 ± 0.58 at T2 and 2.08 ± 0.73 at T5. A consistent and slight increase in STL was also observed over time in both groups. The mean STL was slightly greater in the PSRC group than in the PMSC group at every time point, but the differences were insignificant. Overall, the mean STL increased from 1.99 ± 0.93 mm (T2) to 2.38 ± 0.94 mm (T4) and stayed consistent until the end of the study.

The mean PD was obtained by averaging the measurements of the six sites around each implant. At any given time point, intergroup differences did not reach the level of statistical significance (Table 2). PD increased slightly

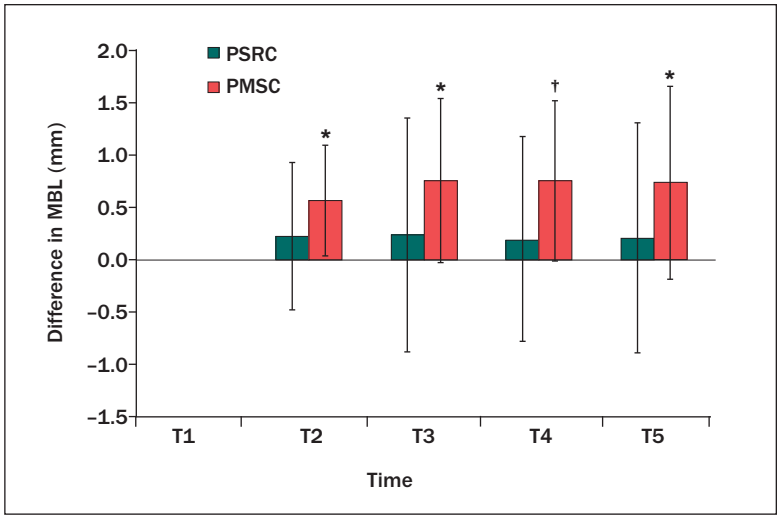


Fig 3 Marginal bone changes following implant placement. For details, please refer to Table 2. *Significantly different between groups ($P < .05$; *t* test); †significantly different between groups ($P < .01$; *t* test).

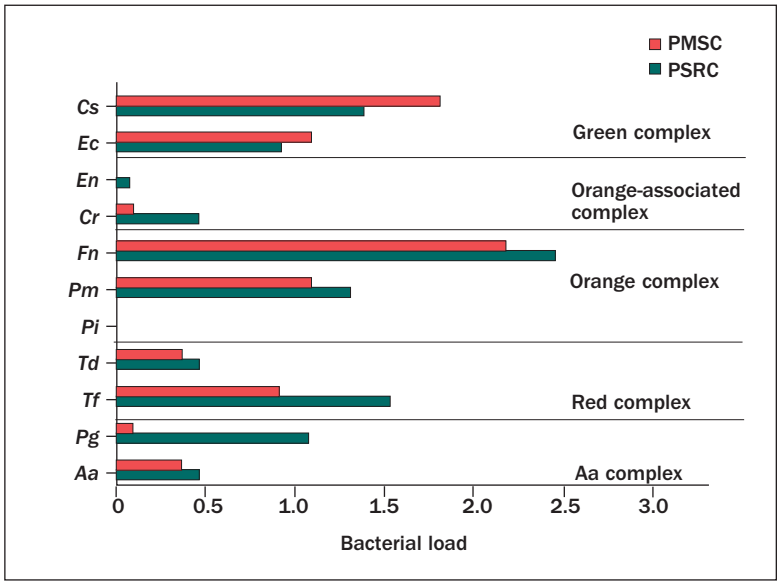


Fig 4 Comparison of the microbial profiles of the test and control groups. Diverse peri-implant microbial flora was found at 12 months postloading (T5), with no intergroup difference. *Cs = Capnocytophaga* species; *Ec = E corrodens; En = Eubacterium nodatum; Cr = C rectus; Fn = F nucleatum/periodontium; Pm = P micros; Pi = P intermedia; Td = T denticola; Tf = T forsythia; Pg = P gingivalis; Aa = A actinomycetemcomitans.*

over time. In the test group, it changed from 2.01 ± 0.70 mm (T2) to 2.82 ± 0.84 mm (T5), whereas it increased from 1.96 ± 0.89 mm (T2) to 2.94 ± 0.87 mm (T5) around control implants. A significant time effect was observed ($P = .04$) between T3 and T5.

The MBL measured at T1 was used as a reference for the later marginal bone alterations (Table 2, Fig 3). The MBL values at T1 were 0.22 ± 0.49 mm and 0.036 ± 0.13 mm in the PSRC and PMSC groups, respectively. The MBL change between T1 and T2 was 0.23 ± 0.36 mm in the test group and 0.57 ± 0.27 mm in the control group (statistically significantly different; $P = .01$). A relatively minimal MBL change was found in the PSRC group at T5 (0.21 ± 0.56 mm). On the other hand, the MBL alteration in the PMSC group increased from 0.57 ± 0.27 mm between T1 and T2 to 0.74 ± 0.47 mm between T1 and T5. Significant intergroup differences were noticed between T1 and subsequent time points ($P = .005$ to $P = .02$). Although time as a fixed variable did not have a significant effect on marginal bone changes, the majority of bone loss in both groups occurred between T1 and T2. Soft tissue thickness and implant diameter did not exert any significant effect on MBL.

The CBCT results are summarized in Table 3. In general, the ridge dimensions increased in both height and width throughout the observation period. RW1 increased from a mean of 7.52 ± 1.24 mm before surgery to 8.21 ± 1.04 mm at T5 ($P = .03$). Greater vertical and horizontal dimensions were found in the PSRC group, both presurgery and at T5, but these differences were not statistically significant. The presence of bony plate perforation was noticed in the CBCT images in three cases (one buccal dehiscence and two buccal fenestrations). These were in one PSRC patient and two PMSC patients. All three patients were asymptomatic clinically.

Table 3 Within-Group and Between-Group Comparisons of CBCT Measurements

Parameter	PSRC	PMSC	Total mean	*P* (PSRC vs PMSC)
RH (mm)				
Prior surgery	16.92 ± 2.59	16.65 ± 3.36	16.78 ± 2.94	0.82
T5	17.53 ± 2.79	16.20 ± 3.10	16.95 ± 2.94	0.29
P	.57	.75	.84	–
RW1 (mm)				
Prior surgery	7.76 ± 1.19	7.28 ± 1.29	7.52 ± 1.24	0.34
T5	8.34 ± 1.08	8.03 ± 1.03	8.21 ± 1.04	0.50
P	.20	.15	.03*	–
RW2 (mm)				
Prior surgery	9.87 ± 2.24	8.60 ± 2.08	9.23 ± 2.21	0.1457
T5	10.19 ± 2.06	9.89 ± 2.15	10.06 ± 2.06	0.7361
P	.71	.16	.19	–
No. of perforations	1	2	3	–

Table 4 Comparison of Patient Satisfaction Scores Between Groups

	Patient satisfaction scores			
Time/parameter	PSRC	PMSC	Total mean	*P**
T1				
Pain	1.54 ± 0.52	1.31 ± 0.48	1.42 ± 0.50	.25
Swelling	1.23 ± 0.60	1.08 ± 0.28	1.15 ± 0.46	.41
Bleeding	1.38 ± 0.65	1.15 ± 0.38	1.27 ± 0.53	.28
Overall discomfort	1.46 ± 0.52	1.31 ± 0.48	1.38 ± 0.50	.44
T5				
Comfort	1.15 ± 0.38	1.00 ± 0.00	1.08 ± 0.28	.19
Function	1.15 ± 0.38	1.00 ± 0.00	1.08 ± 0.28	.19
Esthetics	1.31 ± 0.63	1.18 ± 0.40	1.25 ± 0.53	.57
Overall satisfaction	1.15 ± 0.38	1.00 ± 0.00	1.08 ± 0.28	.19

*$P < .05$ indicates a significant difference between groups (*t* test).

Microbial Analysis and Patient Satisfaction

Diverse microbial profiles were noticed, which might have resulted in nonsignificant differences in the numbers of species seen in the two groups (Fig 4).

Overall discomfort was valued as 1.46 ± 0.52 and 1.31 ± 0.48 in the test and control groups, respectively ($P > .05$) (Table 4). At the end of the study, the mean values were 1.08 ± 0.28, 1.08 ± 0.28, 1.25 ± 0.53, and 1.08 ± 0.28 with reference to comfort, function, esthetics, and satisfaction, respectively. No statistically significant differences between groups were noticed in patient assessments.

DISCUSSION

The results of the current study suggest the feasibility and predictability of single implant placement with a flapless approach and an early loading protocol in the esthetic zone. The overall implant survival rate was comparable with those seen in previous studies using either the flapless technique[15,26] or an early loading protocol.[18,27] The mean marginal bone loss was less than 1 mm in both groups, and soft tissue profiles remained stable for up to 1 year of function. Additionally, all patients in both groups expressed high satisfaction.

Significantly less marginal bone loss was observed in the PSRC group, a result that agrees with previous reports.[28,29] However, a recent prospective study[30] failed to support the superiority of PS in reducing marginal bone loss. The conflicting results may be a result of heterogeneity in experimental designs, including experimental periods, implant types and locations, and surgical techniques. In essence, the necks of the implants were different in the present study in that the dimensions of the smooth collar in the PSRC and PMSC implants were 0.1 mm and 1 mm, respectively. Previous studies suggested favorable

outcomes around implants with a rough collar,[31,32] with varying effects on bone preservation depending on the experimental model and implant apicocoronal positioning. From the results of the present study, it is speculated that, in addition to the bone-preserving effect of PS during the loading period, the rough collar in the PSRC group might have contributed to less bone resorption during early healing.

In the present study, the change in crestal bone levels up to 1 year postloading in the PSRC group was 0.21 ± 0.56 mm, which is better than documented in previous meta-analyses.[33,34] The superiority in the current finding may be attributable to both patient and technical aspects. First, all patients maintained good oral hygiene throughout the study. Second, most patients had thick peri-implant mucosa.[35] And finally, the flapless approach might also have helped decrease initial bone loss. Marginal bone loss was less in the present study than in previous studies in which flaps were reflected for implant placement.[10,36] In addition to the variations in experimental designs, the authors speculated that the combination of a PSRC implant design with a flapless surgical technique might have contributed to the favorable outcome in bone remodeling.

In a case series, Canullo and Rasperini evaluated the soft tissue response to PS implants after a mean of 22 months of follow-up.[37] During the follow-up period, the papillary level increased, with a mean value of 0.25 mm.[37] The result is in accordance with the current findings. In addition, the trend of an increase in PPI found in the current study agrees with the results of several studies that used flapless implant surgery[13,26] or an early loading protocol.[38,39]

Patient satisfaction is rarely a point of convergence in the literature. Telleman and coworkers conducted a series of studies comparing patient satisfaction with PS and PM implants before and after implant treatment.[40,41] After treatment, a significant increase was observed in patients' self-confidence, along with patient satisfaction with esthetics and chewing function. No difference was found in preference for the PS vs PM implants.[40,41] Comparable findings were discovered in the current study.

Researchers have investigated the relationship between the presence of periodontal pathogens and progression of periodontal destruction.[42,43] It has been suggested that the presence of putative periodontal pathogens might not lead directly to bone alterations.[43] This conclusion, in fact, corresponds well with the current findings. Most of the putative periodontal pathogens detected in the present study showed no significant differences in concentration at the end of the study, although significantly more bone loss was seen in the PMSC group. Identical conclusions were drawn in a comparative study that evaluated the impact of PS on short implants.[8] Since a high level of oral health was a prerequisite for all participants in both studies, the concentration of periodontal pathogens was considered minimal, which might have resulted in unremarkable microbiologic effects on the outcomes. Furthermore, it should be noted that peri-implant microbial profiles are also affected by the flora around the adjacent natural dentition via intraoral transmission.[44] In the present study, relatively lower numbers of bacteria were randomly observed in certain patients with PMSC implants, leading to higher mean bacterial levels at the PSRC sites. This may have resulted from cross-contamination of bacteria from the adjacent natural dentition. It is difficult to draw strong conclusions regarding the association in the current study, since the microbial sampling was performed only on implant sites and at only one time point.

Limitations of the present study also include its short follow-up period, different implant diameters between groups, and possible errors in CBCT measurements caused by beam-hardening artifacts and scattering. The magnitude of marginal bone resorption may also have been underestimated via radiographic assessments; no re-entry was performed to verify measurements in this project.[45]

CONCLUSIONS

With the limitations of the study, the following conclusions can be made.

1. Platform-switched implants with a rough collar preserved marginal bone by a mean of 0.53 mm more than standard non–platform-switched implants with a smooth collar. The majority of bone loss occurred during the first 3 months postoperatively.
2. Computer-aided flapless surgery in conjunction with an early loading protocol is a feasible and predictable approach, with a 100% survival rate after 1 year of function in this population.
3. The flapless approach helped to maintain soft tissue profiles in the esthetic region.

Further longitudinal studies are needed to verify the long-term effects of platform-switched implants with a rough collar.

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