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Original Article

Effect of Platform-Switched Implants and Papilla Preservation Flap Design on Interproximal Bone Levels: A 6-Month Randomized Clinical Study

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ABSTRACT

Sufficient, high-quality bone surrounding a dental implant—in particular, the crestal ridge—is fundamental to long-term treatment success. Accordingly, crestal bone maintenance ought to be prioritized well before prosthetic planning commences. A variety of approaches for averting crestal bone deterioration have been documented. Implants employing platform switching represent one such strategy. This investigation sought to determine whether platform-switched implants, combined with a papilla-sparing flap technique, could effectively reduce interproximal bone resorption at single-implant sites. Conducted as a parallel-arm randomized controlled trial, the study enrolled 21 subjects each requiring a single implant, who were assigned at random to three arms: Group A: Platform-matched implants paired with standard flap reflection, Group B: Platform-switched implants paired with standard flap reflection, and Group C: Platform-switched implants paired with a papilla-sparing flap design. Clinical indices (PI, GI, mPI, and mGI scores) and radiographic measurements were recorded to compare treatment outcomes among the three protocols. Subjects in Group A exhibited a mean crestal bone reduction of 1.292 ± 0.084 mm at the 3-month interval and 1.804 ±.038 mm at the 6-month interval. Group B subjects demonstrated mean losses of 0.631 ± 0.092 mm at 3 months and 1.139 ± 0.080 mm at 6 months. Group C subjects recorded a mean crestal loss of 0.327 ±.075 mm at 3 months and 0.544 ± 0.084 mm at 6 months. The data reveal that the smallest degree of crestal bone resorption was observed in Group C, followed sequentially by Group B, while the greatest resorption occurred in Group A. It may therefore be inferred that coupling platform-switched implants with a papilla-sparing flap design constitutes the most effective approach for curtailing bone loss, with platform-switched implants alone being the next most beneficial option.

Keywords: Crestal bone loss, Dental abutments, Platform switching, Single-tooth implants, Surgical flaps

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Introduction

Post-restorative remodeling of crestal bone height is a principal benchmark of implant success [1]. Over time, crestal bone diminution has been associated with numerous factors [1, 2]. A range of causative factors have been identified as influencing peri-implant crestal bone resorption, including reconstitution of the biologic width, operative trauma, the presence of a microgap, and excessive occlusal forces [1-4]. Similar to a natural dentition, an implant establishes a biological width; this reformation occurs when the fixture is uncovered during second-stage surgery, thereby precipitating crestal bone resorption [5, 6]. Proponents have also stated that, following submerged abutment connection, a minute gap persists between the implant and abutment—the implant-abutment junction—harboring an inflammatory cellular infiltrate. This zone of inflammatory cells reportedly forms a 1.5 mm hemispherical domain around the implant-abutment junction, leading to osseous resorption and crestal bone loss [6, 7]. Peri-implant crestal bone loss may additionally arise from occlusal overburdening of the immature bone-to-implant

contact during early functional loading. This phenomenon may account for the "saucer-shaped" osseous defect encircling the implant throughout its first year in service [3]. Practitioners broadly utilize two-component implant assemblies for tooth replacement. Owing to manufacturing tolerances, implants and their associated abutments cannot be fitted with absolute precision, leaving a microscopic gap between the components—commonly called a microgap. The unhindered transit of microorganisms and their metabolic products across this microgap (microleakage) sustains persistent inflammation at the IAJ, a phenomenon researchers have frequently observed around the implant collar [8].

In an effort to counteract these putative influences, Lazzara and Porter [6] put forward the innovative notion of "platform switching" implants.

Application of the platform switching (PLS) principle conserves crestal bone, and this method warrants clinical adoption to bolster the comprehensive success of dental implant therapy [9, 10]. In essence, this involves repositioning the implant-abutment junction platform medially, either by fitting a narrower-diameter abutment atop a wider-diameter implant or by modifying the abutment contour, thus furnishing a horizontal shelf for biological width formation while simultaneously reducing the dimensions of the microgap and displacing the inflammatory cellular infiltrate outward from the adjacent crestal osseous tissue [11].

Additionally, it may confer benefit by displacing the zone of force concentration away from the crestal bone-implant interface and diverting masticatory loading vectors axially along the implant body [9, 12].

Operative injury inflicted during flap reflection likewise serves as a major factor prompting crestal bone resorption [2, 13-16], since creating a crestal releasing incision to place the implant entails lifting a mucoperiosteal flap, thereby interrupting the vascular supply from the overlying soft tissue to the underlying bone. Given that the subjacent bone already possesses a meager blood supply, the result is heightened osseous resorption during the earliest phase of repair. In contrast, when the interproximal papillary tissue is conserved during flap elevation, the osseous vascular supply remains intact, thereby lessening the magnitude of peri-implant crestal bone deterioration and facilitating optimal hard- and soft-tissue outcomes [17].

Having recognized this, a systematic evaluation was conducted to gauge the effectiveness of PLS on interproximal crestal bone loss at single-implant sites, and to ascertain whether altering the flap configuration yields supplementary advantages in constraining bone resorption. The objectives were (1) to radiologically quantify interproximal crestal bone loss adjacent to single implants utilizing three separate treatment approaches, namely platform-matched implants with standard flap design, platform-switched implants with standard flap design, and platform-switched implants with a papilla-sparing flap design; and (2) to contrast the radiographic bone loss differences apparent among these three treatment modalities.

Materials and Methods

Study population

A total of 21 individuals exhibiting single-tooth edentulous spaces were enrolled in this study. Participants of both genders (12 males and 9 females), spanning an age bracket of 24–49 years (mean = 39.10 ± 6.69 years), were sourced from the out-patient clinic of a private dental teaching hospital upon satisfying the eligibility requirements. Ethical clearance for this project (Ethical Committee no 12022) was issued by the Ethical Committee of Manipal College of Dental Sciences, Mangalore, Manipal Academy of Higher Education, Manipal on 18 October 2014. Before study initiation, all potential participants were briefed on the aim and format of the clinical investigation and were required to sign a consent document.

The admission criteria comprised (1) individuals aged 18 to 55 years, (2) no medically compromising conditions, (3) single edentulous spans with D1/D2 bone quality (according to the Misch classification), (4) adequate oral hygiene status, and (5) willingness to return for follow-up evaluations over a 6-month window after delivery of the prosthesis.

The grounds for exclusion were (1) individuals with a full mouth plaque index score and a full mouth bleeding index score exceeding 25%, (2) implant receptor sites exhibiting a bone crest width inferior to 7 mm, (3) sites manifesting interproximal or buccal osseous defects, (4) sites presenting with an acute infectious process, (5) tobacco users, (6) individuals diagnosed with psychotic disorders or parafunctional oral activities, (7) pregnant or nursing mothers, (8) subjects with unregulated diabetes mellitus, (9) subjects possessing a medical history of bisphosphonate drug intake, and (10) radiation therapy administered within the previous 6 months.

Study design

The trial employed a parallel-group randomized controlled methodology. The group assignment was generated using a computerized random sequence.

Participants were distributed uniformly into three treatment arms: (1) Group A: implants with a matched platform combined with a conventional flap technique, (2) Group B: implants with a switched platform combined with a conventional flap technique, and (3) Group C: implants with a switched platform combined with a papilla-sparing flap method.

Pre-treatment records

A detailed medical and dental history was compiled for every subject. Periapical and panoramic radiographs were taken to determine distances relative to the designated anatomical landmarks. Cone-beam computed tomography scans were used to classify bone quality based on grayscale values, and only sites exhibiting D1/D2 bone characteristics (according to the Misch classification scheme) were selected across all cases. Implant dimensions were tailored to each patient's individual bone height and width measurements. Periodontal status was documented using the clinical parameters plaque index (PI) and gingival index (GI). Study casts were poured, and intraoral photographs were captured.

Presurgical protocol

Following the initial work-up and treatment planning sequence, every patient underwent a Phase I therapy regimen. Customized instruction on self-administered plaque-control techniques was delivered, emphasizing their impact on successful implant outcomes. After a 2-week interval, only those who had consistently demonstrated excellent oral hygiene standards proceeded to the operative stage. One day preceding the surgery, a prophylactic antibiotic course was initiated (Amoxicillin 500 mg three times per day for 5 days) to guard against postoperative infection.

Surgical protocol

After verifying all pre-treatment records, patients who met the inclusion criteria were prepared for implant surgery. The oral cavity was rinsed preoperatively with a 0.2% chlorhexidine solution (PlakilTM India), after which the operative field was prepped and draped. Local anesthesia was delivered using 2% lignocaine hydrochloride containing 1:200,000 adrenaline (Astra Zeneca Pharma, India Ltd).

Description of flap design

Conventional flap: A mid-crestal incision was performed using a No. 15 BP blade, complemented by sulcular incisions along the proximal surfaces of the adjacent teeth. The resulting flap was elevated with a periosteal elevator.

Papilla-sparing flap design: Elevation of a full-thickness mucoperiosteal flap was carried out. The interproximal papillae on both the mesial and distal aspects were conserved (1–2 mm) and deliberately excluded from the elevated flap; two vertical releasing incisions were then outlined. The lingual or palatal terminals of these vertical cuts were linked by a horizontal incision that penetrated down to the osseous surface. The mucoperiosteal layer was carefully separated with a small-sized elevator, safeguarding the papillae from any injurious or traumatic handling. The reflection of the mucoperiosteal flap was extended only as far as required to accommodate the implant fixtures [17].

Implant placement and suturing: Sequential osteotomy preparation was performed using drills of appropriate diameters until the prescribed depth was reached. The fixture size was determined on an individual basis, corresponding to each patient's bone height and width. Across all three groups, implant platforms were positioned at the crestal bone level. The cover screw was inserted, and primary soft-tissue closure was achieved with interrupted sutures using non-resorbable 3-0 black silk (Ethicon, Johnson & Johnson Ltd., India).

Postoperative care and instruction

The antibiotic regimen was continued post-surgically for the full prescribed duration. Patients also received analgesic coverage (Paracetamol 500 mg SOS) for pain management. Rinsing with 0.2% chlorhexidine gluconate was prescribed (twice daily for 4 weeks). Suture removal was completed after the first postoperative week. Recall visits were subsequently scheduled at the 15-day and 30-day milestones to enable further assessment and maintenance of plaque control. All patients were recalled at 1, 3, and 6 months postoperatively for continued evaluation. At every follow-up appointment, oral hygiene guidance was reiterated.

Second-stage surgery

After an osseointegration latency period spanning 3 to 6 months, the fixtures were uncovered through a second-stage procedure conducted with a conservative surgical philosophy. A plus-shaped incision was made, aiming to restrict the extent of incision lines wherever possible while conserving the adjacent papillae. Once the implant was exposed, the cover screw was removed, and a healing abutment was secured to the implant body; the soft tissue margins were then snugly approximated around the healing abutment.

About 4 weeks after the second-stage surgery, patients returned for the impression appointment. Impressions

were obtained via a closed-tray technique using elastomeric impression compound. After cast fabrication, subjects allocated to Group A received conventional platform-matched abutments. In contrast, those in Groups B and C were fitted with custom-designed platform-switched abutments (MDMACF1, Friction F1T cementing, MIS seven Implant system, Confident Sales India Pvt Ltd). The definitive prosthetic crown was manufactured and delivered. The delivery appointment served as the baseline reference point for all radiographic and clinical recordings. All radiographic and clinical parameters were documented on the day of prosthesis insertion (baseline) and again at 3-month and 6-month intervals thereafter.

Clinical measurements

The clinical parameters itemized below were assessed at the time of prosthesis delivery (baseline) and subsequently at 3-month and 6-month post-insertion intervals:

- (1) PI: Silness and Loe [18].
- (2) GI: Loe and Silness [19].
- (3) Modified plaque index (mPI): Mombelli *et al*. [20].
- (4) Modified gingival index (mGI): Apse *et al*. [21].

Each recorded value was transcribed onto the dedicated case documentation sheet designed for this investigation and then subjected to statistical evaluation.

Radiographic technique

Intraoral radiographic exposures were obtained for the entire study sample at baseline, at the 3-month recall, and at the 6-month recall following prosthesis insertion. A uniform intraoral periapical view was acquired at each designated site using the long-cone paralleling technique with a film-holding assembly (XCP, RINN, Dentsply Illinois, USA). The entire radiograph was captured on intraoral "E" speed film (Kodak Carestream Health Inc., New York, USA) superimposed over a millimeter grid template. These templates represent pocket-style grid mounts compatible with intraoral film dimensions; grid markings are printed in both vertical and horizontal orientations at 1-mm spacing, with accentuated lines at 5-mm increments. Uniformity of projection geometry was upheld through customized occlusal registrations fabricated from RamitecTM bite registration material (3M ESPE, Minnesota, USA) and secured to the film-holding device for each radiographic acquisition.

Radiographic measurements

Crestal bone height

Crestal bone height was established by gauging the interval separating the first thread of the MIS seven implant from the most coronally situated point along the interproximal crestal bone margin. The linear radiographic distance was ascertained by plotting a line originating at the reference landmark (first thread of the fixture) and terminating at the alveolar crest (or the most coronal extent of the interproximal crestal bone) on both the mesial and distal orientations of the implant; the length of this plotted line was subsequently rendered by the analytical software, furnishing the bone height measurement. An average was then computed from the two proximal values. Recordings were made at the time of loading and at the 3- and 6-month time points after prosthesis insertion. All radiographs were digitized using a flatbed scanner (HP Scanjet, Hewlett-Packard, Palo Alto, CA, USA). Every radiographic assessment was undertaken in ImageJ, a platform developed by the National Institutes of Health, USA, specifically for radiographic-based measurements. The workflow began by importing the digitized image into ImageJ. Thereafter, using the straight-line selection function, a segment covering a 1-mm grid increment was delineated, and the scale factor was established by relating that linear distance to its equivalent in pixel units. Following scale calibration, the vertical bone height was determined using the identical straight-line selection tool, spanning from the most coronal edge of the alveolar bone down to the first thread of the implant on both mesial and distal faces.

Measurement

For each treatment group, the variation in interproximal crestal bone height was calculated between the baseline reading and the 3-month value, between the baseline reading and the 6-month value, and between the 3-month and 6-month values.

Statistical analysis

All statistical processing was performed within SPSS software, version 13. P-values falling beneath 0.05 were taken to signify statistical significance.

Primary outcome

The mean bone loss across the three treatment groups from baseline to the 3-month and 6-month follow-ups was analyzed using the Friedman test. Within-group evaluations covering the baseline-to-3-month, 3-to-6-month, and baseline-to-6-month spans were executed using the Wilcoxon signed-rank test. Between-group contrasts of mean bone diminishment were analyzed via the Mann–Whitney test.

Secondary outcome (PI, GI, mPI, mGI)

Within-group contrasts at the successive assessment points were performed employing the Wilcoxon signed-rank test. Between-group contrasts were undertaken through the Mann–Whitney test.

Results and Discussion

All 21 enrolled individuals attended every follow-up visit throughout the full 6-month period and received their definitive prostheses. No participant exited the study prematurely. No fixture failures were registered at any point during the trial. Across the three study arms, 13 implants were situated in mandibular first molar positions, 6 in maxillary incisor positions, and 2 in maxillary first molar positions. The distribution of implant sites among groups showed no statistically significant difference (P = 0.387, NS). Fixture diameters ranged from a minimum of 3.75 mm to a maximum of 5 mm, while implant lengths spanned from 8 mm up to 13 mm throughout the entire sample. Neither the comparison of diameters (P = 0.686, NS) nor that of lengths (P = 0.611, NS) yielded statistically significant intergroup differences.

Radiographic measurements

The mean crestal bone levels documented from baseline to the 3-month and the 6-month milestones across the three groups are detailed in **Table 1**. Within-group comparisons of mean crestal bone loss across the baseline-to-3-month, baseline-to-6-month, and 3-month-to-6-month intervals for all three cohorts were carried out with the Wilcoxon signed-rank test **(Table 2)**. Subjects belonging to Group A demonstrated a mean crestal bone reduction measuring 1.292 ± .084 mm at the 3-month assessment and 1.804 ± .038 mm at the 6-month assessment. Group B subjects showed mean reductions of 0.631 ± 0.092 mm at the 3-month point and 1.139 ± 0.080 mm at the 6-month point. Group C subjects recorded mean reductions of 0.327 ± 0.075 mm at the 3-month mark and 0.544 ± 0.084 mm at the 6-month mark. Between-group discrepancies in crestal bone loss were gauged through the Mann–Whitney test **(Table 3 and Figure 1)**. The highest magnitude of bone change was noted in Group A, followed by Group B, whilst the lowest magnitude was observed in Group C upon completion of the half-year observation span.

Table 1. Mean crestal bone level from baseline to 3 months and 6 months in all three groups.

Group		No.	95% confidence interval for the mean		P-value	Friedman test value	Std. deviation	Mean
			Upper Bound	Lower Bound				
A	Baseline	7	6.023	4.330	0.001[a)]	14.000	0.915	5.177
	At 3 months	7	4.829	2.942			1.020	3.885
	At 6 months	7	4.279	2.467			0.979	3.373
B	Baseline	7	6.272	3.761	0.001[a)]	14.000	1.358	5.017
	At 3 months	7	5.7355	3.036			1.459	4.385
	At 6 months	7	0.040	2.715			1.257	3.877
C	Baseline	7	6.015	4.311	0.001[a)]	14.000	0.921	5.163
	At 3 months	7	5.702	3.970			0.936	4.836
	At 6 months	7	5.537	3.700			0.993	4.618

a) Highly statistically significant

Table 2. Intragroup comparison of mean crestal bone loss from baseline to 3 months, from baseline to 6 months, and from 3 months to 6 months in all three groups (Wilcoxon signed rank test).

Group		P	Standard deviation change (%)	Mean bone loss (mm)		
Group A	Baseline	0.000[a)]	24.95	0.084	1.292	3 months
	Baseline	0.000[a)]	34.84	0.038	1.804	6 months
	3 Months	0.000[a)]	13.19	0.059	0.512	6 months
Group B	Baseline	0.001[a)]	12.58	0.092	0.631	3 months
	Baseline	0.000[a)]	22.71	0.080	1.139	6 months
	3 Months	0.018[b)]	11.58	0.157	0.508	6 month
Group C	Baseline	0.014[b)]	06.33	0.075	0.327	3 months
	Baseline	0.002[a)]	10.55	0.084	0.544	6 months
	3 Months	0.030[b)]	04.50	0.059	0.217	6 months

a) Highly statistically significant, b) statistically significant.

Table 3. Intergroup comparison of differences in mean crestal bone loss (Mann–Whitney test)

Time period	Group	Group B versus Group C	Group A versus Group C	Group A versus Group B	Change (%)
At 3 months from baseline	Group A	0.011[b)]	0.001[a)]	0.002[a)]	24.95
	Group B				12.58
	Group C				06.33
At 6 months from baseline	Group A	0.001[a)]	0.001[a)]	0.002[a)]	34.84
	Group B				22.71
	Group C				10.55
At 6 months from 3 months	Group A	0.027[b)]	0.026[b)]	0.749[c)]	13.19
	Group B				11.58
	Group C				04.50

a) Highly statistically significant, b) statistically significant, and c) nonsignificant.

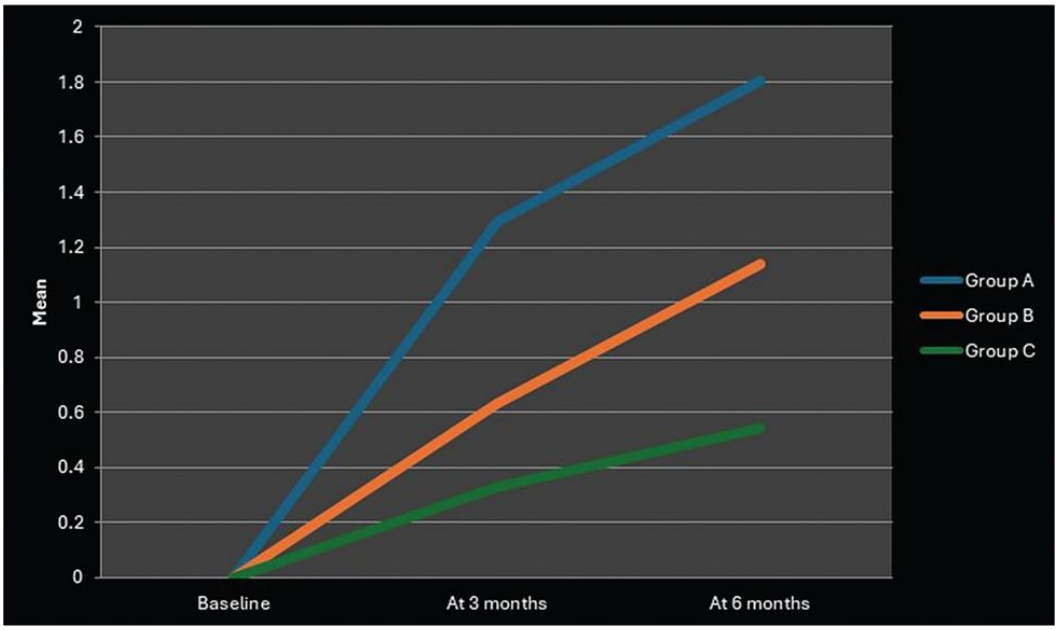

Figure 1. Crestal bone loss in all three groups at baseline, 3 months, and 6 months.

Clinical parameters

PI and GI index: No statistically meaningful change was detected in relation to either of these indices when moving from baseline to the 3-month time point, from baseline to the 6-month time point, or from the 3-month to the 6-month time point within any of the three treatment groups. The mean PI and GI values at baseline, 3 months, and 6 months remained firmly in the low range (< 1).

mPI and mGI: In parallel fashion, neither index displayed a statistically meaningful shift from baseline to the 3-month visit, from baseline to the 6-month visit, or from the 3-month to the 6-month visit across the three groups. The within-group assessment showed a meaningful increase when comparing baseline figures with those at 3 and 6 months. Even so, it warrants emphasis that every score remained uniformly modest (≤ 1).

A cohort of 21 individuals presenting with single-tooth gaps was recruited for this trial in accordance with the defined eligibility criteria, and each participant received a unitary implant fabricated by a single manufacturer. A handful of published works have deployed two distinct implant brands and revealed divergent patterns of osseous remodeling among them. This disparity can be attributed to the differing macrostructural and microstructural attributes of each system. By using an identical implant system for all subjects, the present study successfully neutralized this confounding variable [7, 15, 22].

Another variable that can modulate peri-implant bone loss is the apicocoronal positioning of the fixture relative to the alveolar crest [23]. Throughout this investigation, all fixtures were seated flush with the bony crest to remove this potential source of bias. A deferred-loading strategy was uniformly applied, with prosthetic restorations delivered after 3–4 months of osseointegration latency in mandibular sites and 6 months in maxillary sites. Despite favorable data from recent immediate and early loading regimens, a

conventional delayed protocol was intentionally selected to eliminate any confounding effect of masticatory forces on crestal bone resorption.

The quality of bone differs from the mandibular arch to the maxillary arch and from anterior to posterior segments, a factor that may influence peri-implant crestal bone resorption. In the present work, fixtures were installed in both jaws, spanning anterior and posterior locations. Across the three study arms, implants were placed in the anterior maxillary zones and the posterior molar regions of both the maxilla and mandible. The configuration of implant positions was comparable across the three arms, and statistical testing revealed no meaningful differences in site distribution among the arms. Furthermore, multiple earlier investigations [23-27] that evaluated PLS likewise recruited implants from all intraoral territories. Published evidence indicates that marginal bone loss remains equivalent across arches [25, 26]. As a result, platform switching exerted a uniformly beneficial effect on marginal bone preservation in both jaws. It may therefore be inferred that the varying anatomic locations did not materially skew the final results.

Dental plaque has consistently been identified as a prime driver of crestal bone resorption. As with natural teeth, a biofilm forms on implant surfaces, and this process is shaped by the surface properties (chemical composition, surface free energy, and roughness) of both the implant body and the abutment material [28]. Diligent efforts were undertaken during the trial to keep this factor in check. Over the entire follow-up period, the PI and GI values remained consistently low (< 1). This outcome stemmed from the entry criterion, which admitted patients only when their baseline PI and GI scores were below 20%, coupled with participants' sustained rigorous oral hygiene practices throughout the observation interval.

The mGI and mPI were applied to gauge peri-implant plaque accumulation and the health of peri-implant mucosal tissues at baseline, 3 months, and 6 months; these indices showed no statistically significant differences among the three arms at any time point during the study. It also bears noting that throughout the trial, no recorded value exceeded 1, indicating adequate peri-implant maintenance.

One may deduce from the above that plaque did not act as a confounding variable in this trial, as head-to-head comparisons for each clinical parameter (i.e., GI, PI, mGI, and mPI) were consistently statistically nonsignificant. This observation is in harmony with earlier published reports [25, 26].

In the current trial, the smallest magnitude of bone diminution was observed in Group C subjects, who were managed with a papilla-sparing surgical flap and a platform-switched abutment design, followed in rank order by Group B subjects, who received a platform-switched abutment alone. This outcome mirrors a previous study by Ahmeda *et al*. [5]. The most pronounced bone loss was recorded in Group A, where both a conventional abutment and a standard flap design were utilized [5, 27]. The existing literature indicates that marginal bone loss within the first year of loading reaches no more than 1.5–2 mm, thereafter settling to less than 0.2 mm per year [1, 5, 29-33]. The steepest bone reduction tends to occur within the initial months after implant uncovering and after prosthetic loading [34-36]. A comparable trajectory of bone loss was noted in our data, with the greatest mean bone loss—approximately 1.8 mm—documented in Group A at the 6-month follow-up.

Group A (1.804 ± .038 mm) displayed a relatively larger amount of bone resorption when contrasted with Group B (1.139 ± 0.080 mm) at the 6-month interval. These observations align closely with those published by Vela-Nebot *et al*. [37]. The mean resorption magnitudes recorded from mesial and distal readings in their control arm equaled 2.53 and 2.56 mm, whereas the corresponding values in their test arm—the platform-switched cohort—stood at 0.76 and 0.77 mm after half a year. The mean bone loss figures in both cohorts fell within the same general range as in the aforementioned publication. Beyond that, the present results concur with those generated by earlier long-term evaluations of platform-switched implants [15, 24 38-40].

Flaps are reflected to permit accurate visualization of anatomical reference points and to gauge the sufficiency of bone volume for implant insertion. This maneuver has, however, been correlated with a degree of postoperative discomfort and morbidity. The central concern is a compromise of the supra-periosteal vascular network, which, in turn, triggers alveolar crestal bone resorption [41, 42].

Roman [17] conducted a prospective investigation analyzing interproximal crestal bone loss following the insertion of single-tooth implants using two contrasting flap configurations: a conventional flap and an alternative method in which the neighboring papillae were kept intact. Sites where the interproximal papillae were safeguarded showed a mean interproximal bone reduction of 0.29 ± 0.38 mm at one year after crown placement. On the other hand, sites where the interproximal papillae were not conserved registered a mean interproximal crestal bone reduction of 1.12 ± 1.14 mm at the equivalent one-year post-crown interval. A comparable trend was observed in the

current trial, with less crestal bone loss in the subset of patients treated with the combination of PLS and the papilla-sparing flap design (Group C) compared with those treated with PLS and the conventional flap approach (Group B).

In the present investigation, the mean crestal bone loss in Group A was substantially greater (1.804 ± 0.038 mm) than in Group C (0.544 ± 0.084 mm) at the 6-month evaluation, and this difference was statistically significant. Similarly, the mean crestal bone loss in Group B was greater (1.139 ± 0.080 mm at the 6-month mark) than that in Group C (0.544 ± 0.084 mm at the 6-month mark), again representing a statistically significant difference. To the best of our knowledge, no study to date has directly pitted these two bone-conserving strategies—specifically, PLS and papilla-sparing flap design—against one another. The results of this trial indicate that when these two modalities are blended, a marked decrement in crestal bone resorption is achieved.

Accordingly, the foregoing discussion indicates that the combination of a platform-switched abutment and a papilla-conserving flap approach may help restrain crestal bone resorption around dental implants.

Several limitations are acknowledged within this investigation: (1) restricted sample size: a total of 21 subjects were enrolled. (2) The trial employed a parallel-group design, which carries inherent shortcomings. Given the presence of three separate arms, identifying three single-tooth edentulous spaces within the same individual proved extremely challenging. (3) Gingival biotype was not factored into the analysis, despite its potential to influence bone resorption—an investigation conducted by Canullo *et al*. [38]. The platform-switched and platform-matched abutments did not account for participants' gingival biotype. That study concluded that there was no substantiation that gingival biotype—whether thick or thin—exerts an effect on bone loss; no disparate outcomes emerged between the test and control arms. (4) The follow-up window was brief (6 months). While the existing literature documents that the preponderance of crestal bone loss occurs in the early months following implant insertion, an extended observation period could have added value. (5) Keratinized tissue thickness was not quantified, a variable that might modulate the pace of crestal bone resorption. (6) Assessment was limited to two dimensions: conventional radiographic imaging furnishes two-dimensional data, permitting appreciation of mesial and distal marginal bone height changes alone. Though this restriction has been common to all investigations of this nature, it would nonetheless prove worthwhile for future research endeavors to incorporate three-dimensional imaging methods so that buccal as well as lingual/palatal marginal bone height alterations may also be considered [15, 24 38-40].

Conclusion

Given the boundaries of this trial, the following can be inferred: the combination of a platform-switched implant and a papilla-sparing flap design yielded the least crestal bone loss, followed by platform-switched implants paired with a conventional flap design. In contrast, the greatest bone reduction was observed with the conventional flap design coupled with platform-matched implants. It thus appears that integrating a papilla-sparing flap technique alongside a platform-switched abutment represents a more effective strategy for preserving crestal bone. Given that the present study is constrained by a modest sample size and a short follow-up period, further longitudinal investigations involving larger cohorts are warranted to corroborate these findings and ultimately translate these treatment modifications into everyday clinical practice.

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