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Myron Nevins
Marc L. Nevins

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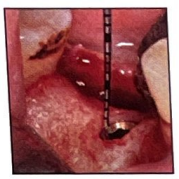
Influence of Implant Placement Depth and Soft Tissue Thickness on Crestal Bone Stability Around Implants With and Without Platform Switching: A Comparative Clinical Trial



Saulius Zukauskas, DDS[1]
Algirdas Puisys, DDS, PhD[2]
Paulius Andrijauskas, DDS[1]
Linas Zaleckas, MD[1]*/Egle Vindasiute-Narbute, DDS*[1]
Tomas Linkevičius, DDS, PhD[3]

This case control study measured early crestal bone changes around subcrestally placed platform-switched implants surrounded by thin soft tissue and compared them with regular, matching-platform implants placed in a supracrestal position and surrounded by thick soft tissue. Sixty-six patients received two-piece internal hex dental implants. Control group patients (n = 33) received implants that had a horizontally matching implant-abutment connection and were placed approximately 0.5 to 1 mm supracrestally. Test group patients (n = 33) received platform-switched implants that were placed about 1.5 mm subcrestally. Clinical examinations were conducted, intraoral radiographs were taken, and statistical analysis was performed. After 2 months, the mean bone loss was 0.2 mm (SD: 0.22 mm; range: 0.1 to 1.2 mm) in the control group and –0.69 mm (SD: 0.65 mm; range: 0 to 2.6 mm) in the test group; this difference was found to be statistically significant (P < .05). After 1 year, mean bone loss was 0.28 mm (SD: 0.36 mm; range: 0.1 to 1.63 mm) in the control group and –0.6 mm (SD: 0.55 mm; range: 0.05 to 1.8 mm) in the test group. Platform-switched implants placed in a subcrestal position in vertically thin soft tissues showed statistically significantly more bone loss than non–platform-switched implants placed supracrestally with vertically thick tissues. Int J Periodontics Restorative Dent 2021;41:347–355. doi: 10.11607/prd.5256

[1]Institute of Odontology, Faculty of Medicine, Vilnius University, Vilnius, Lithuania.
[2]Vilnius Implantology Centre, Vilnius, Lithuania.
[3]Institute of Odontology, Faculty of Medicine, Vilnius University, Vilnius, Lithuania; Vilnius Research Group, Vilnius Implantology Centre, Vilnius, Lithuania.

Correspondence to: Dr Tomas Linkevičius, Institute of Odontology, Faculty of Medicine, Vilnius University; Vilnius Research Group, Zalgirio 117, Vilnius, Lithuania.
Email: linktomo@gmail.com

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Stability of the crestal bone around dental implants is a major concern in dental professions because it is a key factor for treatment success. For decades, dentists focused on alveolar bone qualities and basic surgical principles as main aspects to achieve good outcome.[1] However, guidelines regarding the relation of vertical soft tissue thickness and depth of the implant placement were not covered. Further, it was clinically observed that resorption of the crestal bone is better prevented when tissues surrounding the implants are thicker.[2,3] Bone is protected from bacteria in the oral cavity by biologic width formation.[4] The concept of biologic width was first used by Gargiulo et al, who described the dimensions of the dentogingival junction around human teeth.[5] It has been hypothesized that a similar association might exist between implants as well, and some changes in this relationship may be one of the reasons for early crestal bone loss. This theory first was proved by a canine study wherein thin vertical soft tissues caused crestal bone loss around implants, which established sufficient protection from oral bacteria.[6] Later clinical studies and systematic reviews established that tissue thickness should be evaluated before treatment, as failure to address it may lead to bone resorption.[2,3,7]

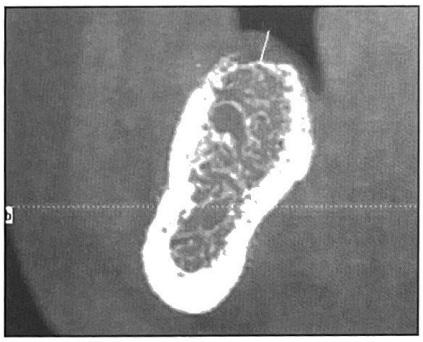

Fig 1 *The blue line represents the vertical soft tissue measurement on the CBCT scan.*

One way to solve marginal bone loss related to thin tissues is to place the implant subcrestally. This method was known for many years but was first scientifically evaluated by Vervaeke et al in clinical split-mouth comparative study, which showed only 0.04 mm of bone loss in subcrestal implants compared to 0.6 mm in the control epicrestal group.[8] Although some data exists, submerging implants deep below bone level is still not well-researched, and it is not clear how bone would react to placement of implants with different designs. Another factor influencing marginal bone loss is the microgap. It was shown by in vitro studies that there is a bacterial leakage and colonization of bacteria along the whole connection of implant, starting from the implant-abutment interface.[9] The microgap is also responsible for formation of inflammatory cell infiltrate in surrounding tissues.[10,11] It is evident that clinicians should take into consideration two main factors of crestal bone loss: vertical soft tissue thickness and the microgap.

Therefore, the present study aimed to measure early crestal bone changes around subcrestally placed platform-switched implants with an internal connection of 45 degrees surrounded by thin soft tissue, and to compare the results with those of control matching-platform implants, placed supracrestally and surrounded by thick soft tissue. The null hypothesis was that there would be no difference between the groups.

Materials and Methods

Patients

The subjects who participated in this study were partially edentulous patients of Vilnius University Zalgiris Clinic, Lithuania. The trial's protocol was approved by Lithuanian Bioethics Committee (no Nr.158200-14-752-270). This study took place from 2015 to 2020 and was conducted according to the principles of the Helsinki Declaration. The inclusion criteria were as follows: *(1)* partially edentulous mandible in the premolar or molar region; *(2)* age ≥ 18 years; *(3)* no medical contraindication for implant surgery; *(4)* sufficient alveolar ridge width (> 7 mm) for placement of a 4.6-mm–diameter implant; *(5)* healed bone sites (at least 6 months after tooth extraction); and *(6)* no need for bone augmentation procedures. Patients were excluded from study if they fulfilled any of following criteria: *(1)* poor oral hygiene; *(2)* suffering from periodontitis; *(3)* inability to attend follow-up visits; *(4)* problematic substance users (smoking, alcohol, etc); *(5)* implant sites were in need of bone augmentation; *(6)* primary stability of dental implant < 35 Ncm during surgery.

Soft Tissue Measurement, Group Allocation, and Surgery

Soft tissue thickness of the implant placement site was measured prior to surgery via CBCT scan, which was done with standard double cheek retractors to separate the soft tissue contour (Fig 1). Depending on vertical soft tissue thickness, patients were divided into either the test group (tissue thickness < 2.5 mm) and or the control group (tissue thickness ≥ 2.5 mm). Surgical procedures were completed by the same surgeon (S.Z.).

After preparing the operating field and injecting local anesthetic (Ubistesin Forte, 3M ESPE), an incision was made at the center of the edentulous ridge. A buccal full-thickness flap was raised with a periosteal elevator, and the vertical soft tissue thickness of the lingual flap was measured using a periodontal probe (Hu-Friedy). After accurate evaluation of vertical soft tissue thickness, the lingual flap was raised, and the surgeon proceeded with implant placement. Patients in the control group received implants with a horizontally matching implant-abutment connection (4.6-mm diameter; Tapered Internal, BioHorizons), which were placed approximately 0.5 to 1 mm supracrestally. Patients in the test group received platform-switched implants (Tapered Plus, BioHorizons), which were placed about 1.5 mm subcrestally (Fig 2). The accuracy of the

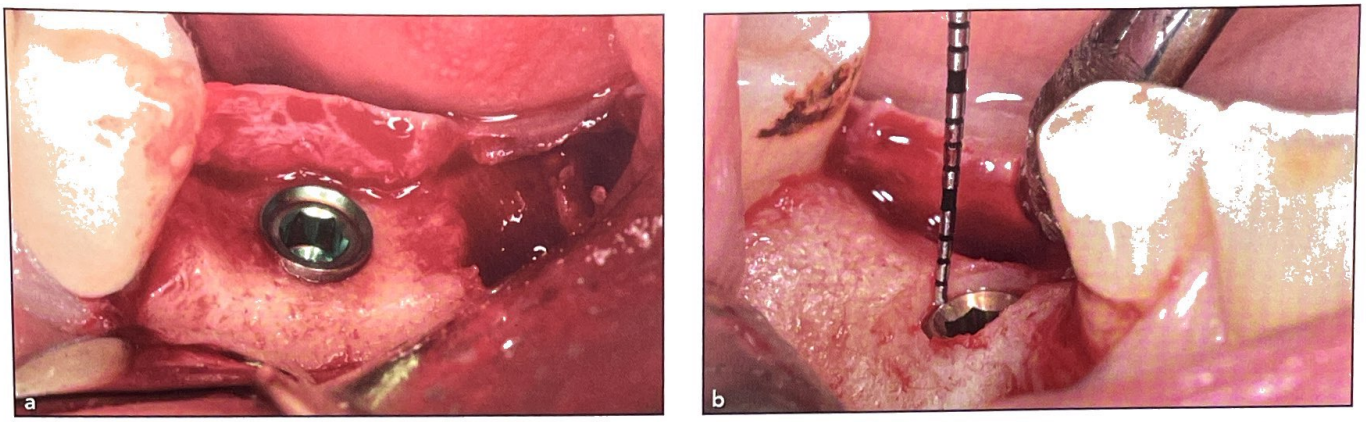

Fig 2 (a) *Control group patients had implants placed in a supercrestal position, and* (b) *test group patients had implants placed in a subcrestal position.*

placement was assured by preparing the osteotomy with a drill (Bio-Horizons) longer than the implant (for example, a 12-mm drill length for a 10.5-mm-long implant). After implant placement, straight emergence profile healing abutments were connected, and the soft tissue was sutured without tension using 5/0 interrupted sutures (Vicryl, Ethicon, Johnson & Johnson).

After surgery, patients were recommended to use mouthwash with 0.12% Eludril (Pierre Fabre) twice a day for 1 week. All patients were prescribed postsurgical antibiotics (1 g amoxicillin; Ospamox; Biochemie) twice daily for 7 days and ibuprofen as needed (400 mg; Ibuprom; US Pharmacia). After 1 week postoperative, sutures were removed. During the healing phase, patients were instructed to use a soft toothbrush to clean the healing abutments.

Prosthetic Restoration

Screw-retained fixed restorations were delivered 2 to 3 months after implant installation. A vinyl-polysiloxane impression material (Express, 3M ESPE) was used for a single-step impression with an individual impression tray. All fixed restorations were radiographically checked for passive fit. After delivery, all patients received dental hygiene instruction using interdental brushes (Curaprox, Curaden).

Clinical Examination

Clinical examination was performed at the 1-year follow-up. During the visit, plaque and bleeding scores were evaluated using the modified Plaque and Bleeding Index, and probing pocket depths were measured.[12]

Radiographic Evaluation

Radiographic evaluation and measurements were completed 2 months after surgery, after prosthesis delivery, and 1 year after prosthesis delivery (Figs 3 and 4). All intraoral radiographs were taken using a Rinn-like film holder and paralleling technique. Parallelism of radiographs was evaluated before proceeding with measurements, and clear visibility of the implant-abutment interface as a "line" was considered a necessary factor. The radiographs were calibrated by setting 4.6 mm as the diameter of the implant. Calibration and measurements were done with ImageJ software (National Institutes of Health). Bone levels were determined as the distance from the implant-abutment interface, which was used as a reference point. Radiographs were analyzed by one independent examiner.

Statistical Analysis

Statistical analysis was performed using Statistical Analysis System package (version 9.2; SAS). Descriptive statistics were used to describe distributions of variables. Z transformation was performed for quantitative data due to non-normal distribution of data. Student *t* test was used to evaluate the differences

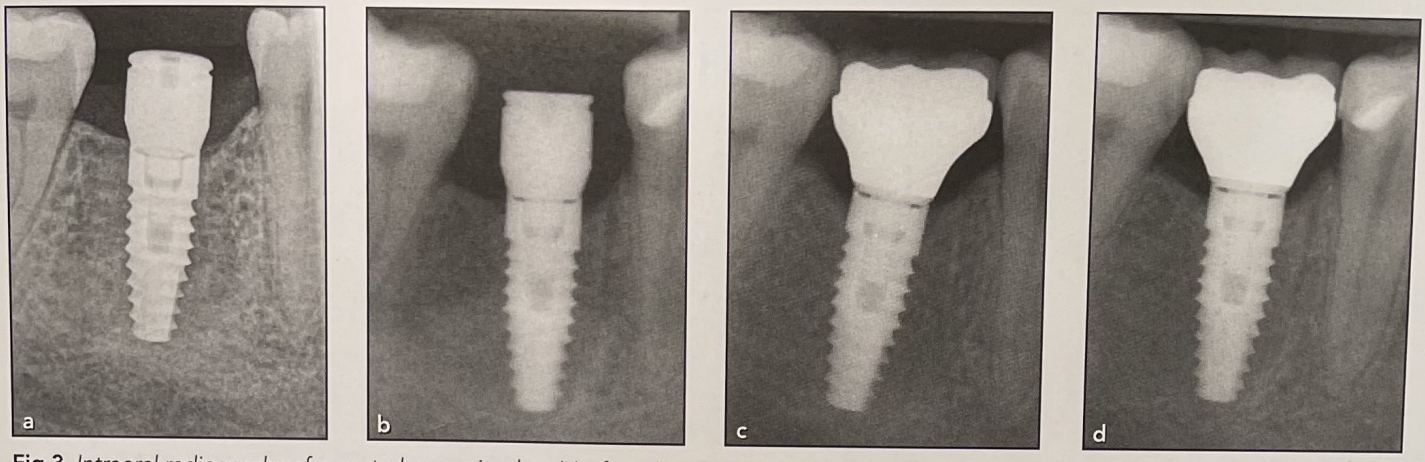

Fig 3 *Intraoral radiographs of a control group implant* (a) *after placement,* (b) *after 2 months,* (c) *after prosthesis delivery, and* (d) *at 1 year.*

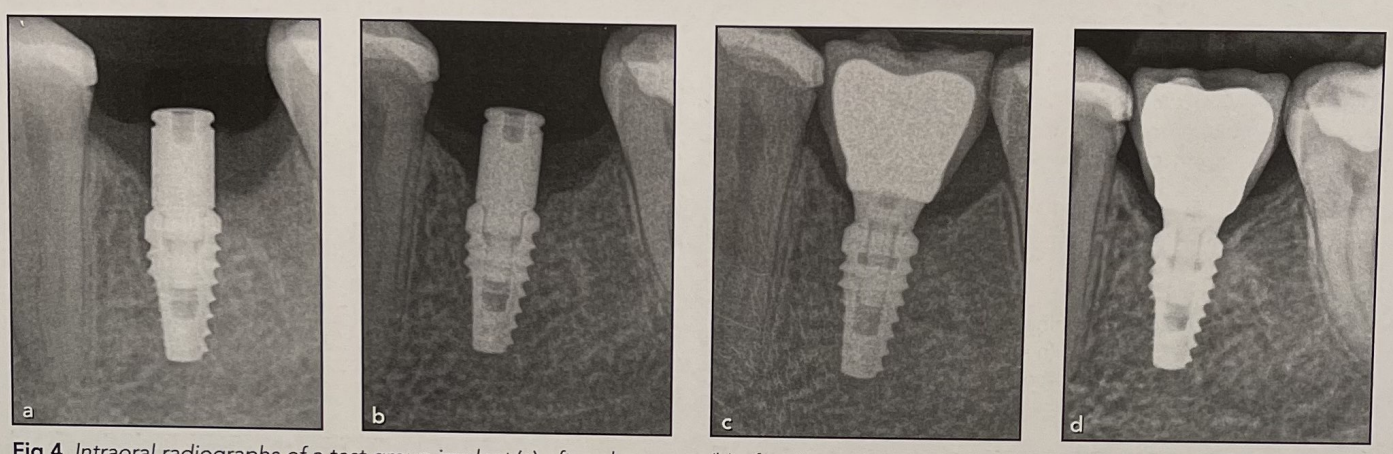

Fig 4 *Intraoral radiographs of a test group implant* (a) *after placement,* (b) *after 2 months,* (c) *after prosthesis delivery, and* (d) *at 1 year.*

between the two independent groups with z-transformed data. Two-way analysis of variance with fixed variables was used to evaluate the differences between factors and their interaction. Wilcoxon signed rank sum test was used to evaluate the difference in dependent variables. A two-tailed *P* value < .05 was considered significant with a confidence interval of 95%.

Results

Initially, 70 patients (43 women, 27 men; age range: 23 to 55 years) participated in this clinical study. Four patients were excluded during the trial (after implant placement): 1 woman was excluded due to pregnancy and being unable to participate in radiographic evaluation of the results, and 3 patients (2 women, 1 man) were excluded due to lack of cooperation and inability to participate in follow-up visits (Fig 5). The final patient sample included 66 patients (40 women, 26 men) who each received one two-piece internal hex dental implant (n = 33 for both control and test groups). The four patients who were excluded from the study were also excluded from statistical analysis (Table 1). No implants failed during the follow-up, resulting in a 100% survival rate. Statistical analysis revealed a significant difference in bone loss after restoration delivery and at 1 year in the control group ($P < .05$), but no statistically significant difference in bone loss between restoration delivery and the 1-year follow-up in the test group ($P = .397$; Table 2). No statistically significant difference was found between groups and pocket probing depth, Plaque Index, and bleeding on probing (Table 3).

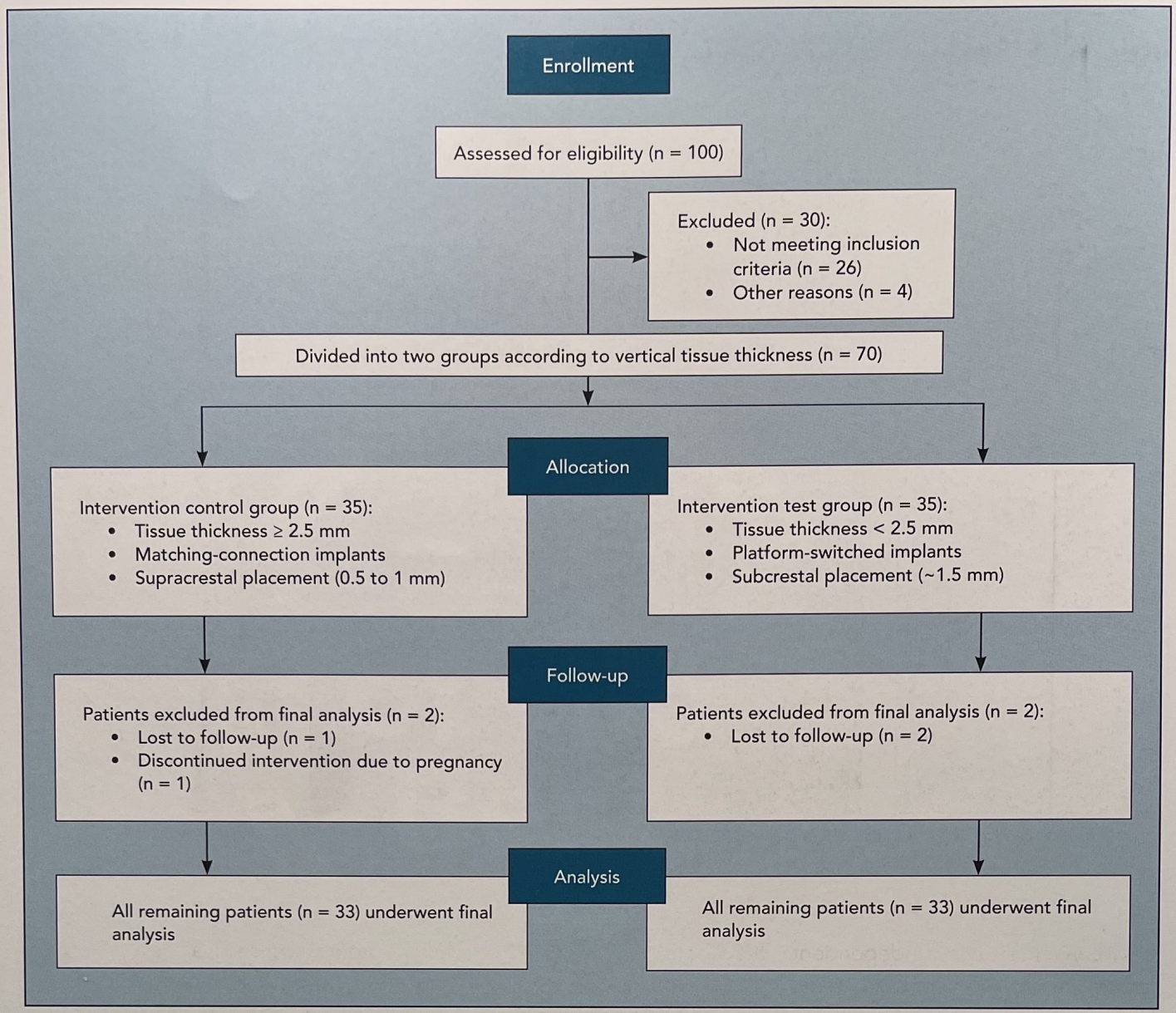

Fig 5 *Flowchart of patient enrollment in the study.*

Discussion

This study investigated whether implant placement depth in relation with soft tissue thickness has influence on crestal bone stability. The results showed that implants in sites with thick soft tissue showed significantly less bone loss compared to implants in sites with thin soft tissue, even if the implants were installed subcrestally. Based on this outcome, the null hypothesis that there would be no difference in bone loss between groups was rejected. It is of note that the control group (with soft tissue thickness ≥ 3 mm and non–platform-switched implants with an internal 45-degree connection) showed minor bone loss (0.28 mm) at the 1-year follow-up. A study by van Eekeren et al showed bone losses of 0.4 mm for bone-level implants and –0.2 mm for tissue-level implants after 1 year of loading.[13]

The results of the control group in the present study can be explained by two major factors: adequate vertical soft tissue thickness and correct implant position, predetermined by the implant design. While tissue thickness was sufficient enough that the protective biologic

Table 1 Crestal Bone Loss and Tissue Thickness in Both Groups After Prosthesis Delivery and After 1 Year of Loading

Parameter	Mean	SD	Minimum	Maximum
Control group (n = 33)				
CBL after prosthesis delivery	0.2	0.22	0.1	1.2
CBL after 1 y	0.28	0.36	0.1	1.63
Tissue thickness	3.04	0.61	2.5	5
Test group (n = 33)				
CBL after prosthesis delivery	0.69	0.65	0	2.76
CBL after 1 y	0.6	0.55	0.05	1.85
Tissue thickness	1.99	0.32	1.4	2.4

CBL = crestal bone loss.
Measurements are shown in millimeters.

Table 2 Comparison of Quantitative Parameters by Wilcoxon Signed Rank Sum Test

	Mean (SD) bone loss, mm		
Group	Prosthesis delivery	1 y	*P*
Control	0.2 (0.22)	0.28 (0.36)	.003
Test	0.69 (0.65)	0.6 (0.55)	.397

Table 3 Independent Samples t Test Analysis of Periodontal Indices Between Groups

	Control group		Test group		
Periodontal index	Mean (SD)	Range	Mean (SD)	Range	*P*
Plaque Index	0.09 (0.29)	0–1	0.12 (0.41)	0–1	.65
Bleeding on probing	0.06 (0.24)	0–1	0.09 (0.29)	0–1	.7
Probing pocket depth, mm	2.36 (0.49)	2–3	2.41 (0.67)	2–4	.75

barrier would form with bone loss, implants were placed supracrestally to distance the microgap from the bone level. Already more than a decade ago, Broggini et al described inflammatory cell accumulation in the microgap of the implant-abutment interface around implants with a matching connection, resulting in increased crestal bone loss.[14] This means that bone loss can be expected even in sites with a thick tissue biotype if the regular-connection implant is placed crestally, resulting in a microgap position at safe distance from the bone level. Failure to completely understand that crestal bone stability is a multifactorial issue may lead to different interpretations of the results. For example, Spinato et al[15] showed no difference in crestal bone stability between thin and thick tissues. However, the implants used in their study had no platform switching and were placed crestally, in which case bone loss is related to too-deep implant

placement rather than tissue thickness.

Many past studies used negative control groups comprised of sites with thin vertical soft tissues to demonstrate that inadequate tissues pose a threat to bone stability.[2,8,13] However, the present authors believe it is unethical to use those situations as a control any longer, as the literature has shown significant evidence that thin tissues cause bone loss, and ethical committees are reluctant to grant permission for research if the outcome is clearly negative for the patient. Therefore, a positive control group with thick tissue was used in the present study and is suggested for future use.

A separate discussion is needed to understand and explain why subcrestally placed platform-switched implants in thin tissues (test group) had greater bone loss compared to matching-connection implants with a thick tissue type (control group). Generally, it was reported that subcrestal implant placement does not have favorable results with all implant designs; Hermann et al showed that deeper placement of matching-connection implants resulted in more bone loss,[16] while Cochran et al showed favorable results in crestal bone when using platform-switched implants in a subcrestal position.[17] Moreover, Vervaeke et al[8] also showed almost no bone loss in subcrestally placed platform-switched implants in thin tissues (0.04 mm); this contrasts the outcome of the present study, which showed 0.68 mm of bone loss with platform-switched implants in thin tissues. Both studies used platform switching as a prerequisite of bone preservation but achieved different outcomes, and the reason might be the differences between connections—or their stability, to be more precise. Vervaeke et al's[8] implants had a 5-degree conical connection while the present study's implants had a 45-degree conical connection. It was shown that the smaller the angle of the conical connection, the more stable it is.[18] Additionally, it is suggested that the deeper the position of the implant in the bone, the more connection stability is important.[19] The test group used platform-switched implants, but the connection was not stable enough and resulted in more bone loss than expected.

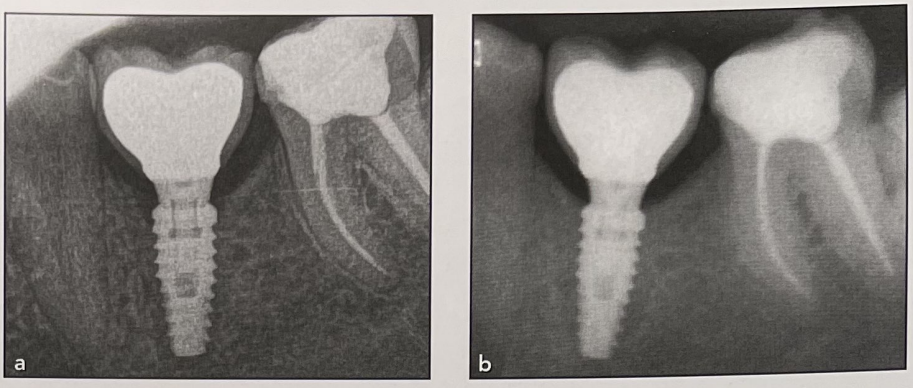

Fig 6 *A case of bone remineralization in a test group patient. Intraoral radiographs were taken* (a) *after prosthesis delivery and* (b) *at 1 year.*

The present study shows that implants without platform switching could maintain stable crestal bone when the surrounding soft tissue is thick. It was interesting to see how platform-switched implants placed subcrestally did not perform better than the control implants placed supracrestally. This may be explained by the fact that Tapered Internal and Tapered Plus implants have the same internal connection. It was shown that implants placed subcrestally have a stable conical connection, as the internal hex lacks sufficient stability to be positioned subcrestally. The present results show bone loss of 0.69 mm after 2 months in these cases, which were improved (0.6 mm) after 1 year (Fig 6). This phenomenon could be explained by an unstable healing implant-abutment connection during the 2-month healing phase and its consequential bone demineralization. After delivery of the screw-retained prosthesis, the implant-abutment connection was more stable, microbial leakage at the interface was reduced, and remineralized crestal bone was seen in many cases in the test group. This phenomenon of remineralization was explained by Linkevičius et al,[19] who observed bone maturation after eliminating cement remnants in

cement-induced peri-implantitis. Puisys et al presented similar bone behavior in a series of case reports.[20,21]

It is impossible to conduct the present study without limitations: It could be argued that groups differed from the beginning (thin vs thick tissues) and did not receive equal treatment, as implants with different designs (platform-switched vs matching-platform) were placed in different relations to the bone level (supracrestally vs subcrestally). However, the goal of the study was to compare different protocols of treatment and how to place implants in different tissue thickness. Scientifically, it would be more correct to use the same implant design in both groups, but that would be incorrect clinically. Using implants with a matching connection in the subcrestal (test) group to match the control group would result in extensive bone loss. Therefore, different implant designs were selected for the different treatment protocols being tested.

Conclusions

Within the limitations of this study, it can be concluded that early bone loss around implants is affected by soft tissue thickness and implant design. Platform-switched implants placed in a subcrestal position with vertically thin soft tissues (test group) showed statistically significantly more bone loss than non–platform-switched implants placed supracrestally when tissues were vertically thick (control group). The test group implants had a moderate crestal bone resorption of 0.69 ± 0.65 mm at 2 months (prosthesis delivery) in spite of subcrestal implant placement. Stabilization of the implant-abutment connections may lead to improvement of the bone stability by an average of 0.1 mm via the process of remineralization.

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The authors declare no conflicts of interest.

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