Review Article

European Journal of Prosthodontics

Access this article online

DOI:
10.4103/2347-4610.148505

Website:
www.eurjprosthodont.org

Quick Response Code:

Platform switching: A step away from the gap

Shefali Singla, Manu Rathee[1], Lalit Kumar, Mili Gupta[2]

Departments of Prosthodontics and [2]Biochemistry, Dr. Harvansh Singh Judge Institute of Dental Sciences and Hospital, Punjab University, Chandigarh, Haryana and Punjab, [1]Department of Prosthodontics, Pandit Bhagwat Dayal Sharma University of Health Sciences, Rohtak, Haryana, India

ABSTRACT

To maintain long-term stability of dental implants, it is important to minimize bone loss around an implant. Several clinical studies have shown a mean crestal bone loss of 1.5-2 mm around dental implants, in the first year after prosthetic restoration, as clinically acceptable. To limit this crestal bone resorption, several modifications are being tried in the implant systems. Platform Switching is one such concept, which uses prosthetic abutments with reduced diameter in relation to the implant platform diameter. This moves the implant abutment junction and supposedly the inflammatory reaction medially, away from the crestal bone, and may thus, minimize the crestal bone loss. Although, it was a serendipitous finding, an increasing number of implant systems have incorporated Platform Switching into their designs, as an innovative feature for preserving the peri-implant bone. A Medline search was carried out using the Pubmed search engine, with keywords Platform Switching in Dental Implants. Twenty-one studies (12 random-controlled trials, fourprospective-controlled clinical studies, and five clinical case series) were selected for review after screening of a total of 123 articles on the basis of the inclusion and exclusion criteria. A detailed review of these articles gave a clear tendency toward the positive impact of Platform Switching on crestal bone preservation, but further long-term, randomized-controlled trials, with uniform criteria, are required to confirm these results.

KEYWORDS: Implant abutment junction, marginal bone loss (MBL), microgap, platform switching

Introduction

Rehabilitation of missing teeth using endosseous root-form implants has been proven to be a predictable and highly successful treatment modality. Implant dentistry has continuously evolved from the original Branemark protocol to include varied techniques and wider applications. The maintenance of the peri-implant bone is a major factor in the prognosis of prosthetic rehabilitation, supported by implants.[1-4] Also it is an important prerequisite for preserving the integrity of gingival margins and interdental papillae.[5,6]

Marginal bone loss (MBL) seems to be unavoidable after implant placement, especially after the abutments are connected. According to Albrektsson, a successful implant might lose an average of 1.5 mm of crestal bone during the first year in function, followed by a marginal bone loss of <0.2 mm during each succeeding year.[2] A combination of mechanical and biological factors contributes to crestal bone loss, including a traumatic surgical technique,[7] stress concentration at the crestal margin due to occlusal loading,[8] location of the Implant Abutment Junction (IAJ), the microgap in relation to the crestal bone and its bacterial colonization,[9,10] establishment of a biological width (2-3 mm) around the dental implants,[9,11] peri-implant inflammatory infiltrate,[12] micromovements of the implant and prosthetic components,[9,13] and repeated screwing and unscrewing.[14]

The ability to further reduce this crestal bone loss may have several advantages, such as, improved esthetics, higher bone-to-implant contact, and primary stability.[15,16] In recent times, several techniques have been developed to minimize MBL such as the non-submerged technique, scalloped implant, rough surface implant neck with microthreads, progressive loading, immediate implant placement, and so on. Platform Switching (PS) is also one such concept, which uses prosthetic abutments with reduced diameter in relation to the implant platform diameter, so as to move the implant abutment junction and supposedly the inflammatory reaction

Address for correspondence:
Dr. Shefali Singla,
House No. 2863, Sector 42-C,
Chandigarh - 160 036, Haryana and Punjab, India.
E-mail: shefali_singla@yahoo.com

medially, away from the crestal bone, and thus, prevent crestal bone loss.

Since the accidental discovery of PS as an implant design modification for crestal bone preservation, various finite element analyses, *in vivo* studies, animal studies, and clinical studies have been conducted in the last decade, to substantiate evidence in favor of this concept. Minimal histological and radiological bone loss has been shown in animal studies where implants have been restored with abutments of mismatched diameter.[17,18] Maeda *et al*. in their 3D Finite Element model noted that PS shifts the area where stress is concentrated away from the cervical bone implant interface, while stress increases in the abutment or abutment screw.[19] In other finite element studies, Hsu *et al*. showed only a 10% decrease in all prosthetic loading forces transmitted to the bone-implant interface, whereas, Tabata *et al*. reported a decrease of 80%.[20,21] Over the last decade clinical trials have been conducted to investigate the influence of PS on MBL around the dental implants, as compared to the platform-matched (PM) implants [Figure 1]. However, the results have been controversial and not definitive. This article aims to investigate if there is an evidence-based rationale for the use of PS as a design feature to limit peri-implant bone loss.

Method of literature search

Search of the electronic database using the Pubmed search engine, with the key words 'Platform Switching in Dental Implants' revealed 123 publications, out of which 97 involved platform-switched implants.

Inclusion criteria

- Human studies, both male and female, published in Pubmed indexed journals in the last 10 years
- Studies involving platform-switched implants with at least one year follow up and considering MBL as one of the outcomes of study.

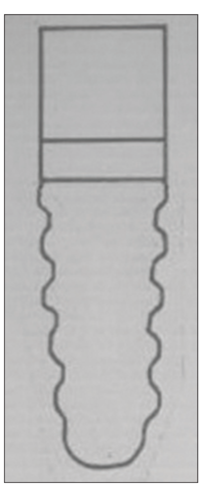

Figure 1: Platform-matched implant

Exclusion criteria

- Biomechanical studies, animal studies, case reports, narrative reviews, and expert opinions
- Human histological studies
- Publications in languages other than English.

After screening the studies on the basis of inclusion and exclusion criteria, by two independent reviewers, 24 studies were identified for detailed evaluation out of which three were eliminated because they were preliminary reports of long-term prospective studies included in the final review [Figure 2-Flow chart]. All the 21 selected studies expressed radiographically detected peri-implant MBL as quantitative data. Twelve of the selected studies were random-controlled trials (RCT), four were prospective clinical-controlled studies (PCCS) without random allocation of the test and control groups, and the remaining five were clinical trials without control groups. Owing to the great heterogeneity in these studies in their own case-control groups, quantitative analysis could not be performed, but a narrative detail on the PS concept and analyses of the results of the studies have been attempted.

Concept of platform switching

It refers to the use of a smaller diameter abutment on a larger diameter implant collar so as to minimize circumferential bone loss. This concept was accidentally discovered in1991, when 3i Implant Innovations (Palm Beach Gardens, FL) introduced implants of larger diameter before producing the corresponding abutments of the same measure. Fourteen years later, evaluation of those treatments in which abutments of lesser diameter were used, revealed better preservation of hard and soft tissues than those where matched abutments were used.[22,23] Gardner, in 2005, discussed the dynamics of hard and soft tissue changes around an implant and introduced the term Platform Switching in a case study.[16] Lazzara and Porter, in 2006, provided a clinical rationale for this implant design. According to them, the biological process resulting in the MBL was altered when the outer edge of the implant-abutment interface was horizontally repositioned in an inward manner and away from the outer edge of the implant platform. Terms like 'Platform Shifting' or 'Platform mismatch' have also been used to refer to this concept.

Rationale behind platform switching

Implant abutment connections in two piece implants, especially those with clearance, fit (index/parallel sides) in their design have a microgap at the implant abutment junction. This microgap provides bacteria with an open channel to penetrate into the implant system and also allows for micromovement of the abutment within the implant.[24] This micromovement further creates movements and stresses on the abutment screw, which cause a loosening and micropumping effect that expels additional bacterial by products and toxins at implant-soft tissue interface and eventually at the osseous crest. On account of the concentration of toxins, the body defenses come into play increasing the inflammatory

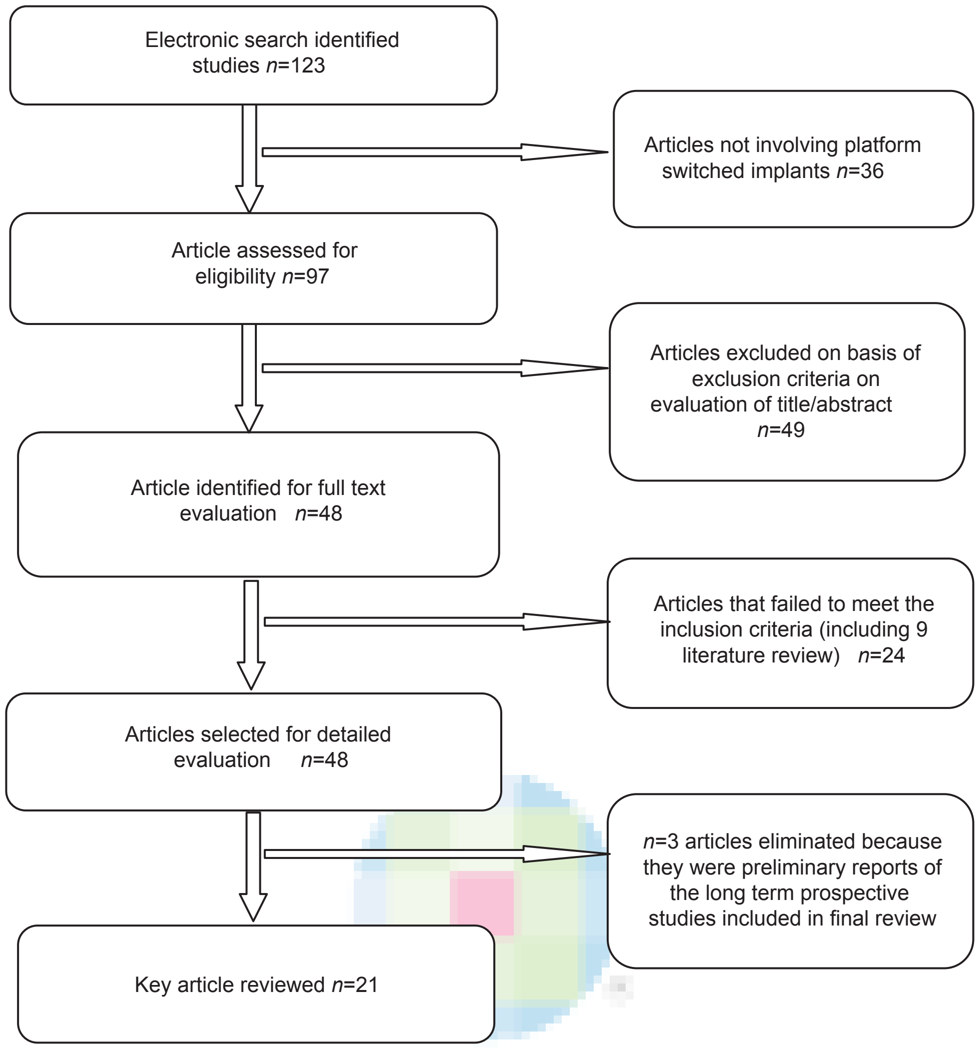

Figure 2: Flow chart depicting selection of articles

response at the crest, causing soft tissue detachment and crestal bone loss. Platform Switching is a simple and effective implant abutment connection modification to control this circumferential bone loss around the dental implants.

Various biological and mechanical theories have been proposed in support of this concept.[22,23] It was suggested that PS displaces IAJ horizontally inwards from the perimeter of the implant platform and adjacent bone, thus increasing the distance between the inflammatory response arena at the microgap and the crestal bone, thereby minimizing the effect of inflammation on the crestal bone remodeling. Also, the angle or step thus created between the abutment and implant allows the biological width to be established horizontally. This means, less vertical bone resorption is required to compensate for the biological seal. The biomechanical theory based on finite element analysis proposed that connecting the implant to a small diameter abutment may limit bone resorption by shifting the stress concentration zone away from the crestal bone-implant interface and directing the forces of occlusal loading along the axis of the implant.[19]

Other modifications in implant design and placement protocol for reducing crestal bone loss

- The crestal module transmits different types of forces onto the bone depending on the surface, texture, and shape. A polished collar and a straight crestal module transmit shear force, whereas, a rough surface with an angled collar transmits beneficial compressive force to the bone and facilitates crestal bone preservation[25,26]
- Use of fine microthreads in the threaded implant neck design; decrease the peak interfacial shear stress on the cortical bone, avoiding further bone loss in this region[25]
- Location of the implant-fixture interface with respect to the crestal bone determines the amount of bone loss occurring to establish the biological width around the implants[15]
- The scalloped implant platform design has been developed to follow osseous architecture and eliminate crestal bone loss[16]
- A nonsubmerged implant placement protocol is a proven way to control or eliminate marginal bone loss[27]
- Additional factors are bone loss secondary to aggression, such as, raising of the mucoperiosteal flap

at the second-stage of surgery, for exposing the screw or colonization by bacteria belonging to the oral flora at the coronal bone and implant junction. A flapless approach at the second stage can be used to remedy this
- Immediate implant placement in the fresh extraction socket.

Switching the platform
Platform Switching can be achieved by:
- Using abutments with a diameter smaller than the implant neck or body width [Figure 3]
- Using an implant design where the neck diameter is increased with respect to the implant body width [Figure 4]
- Using inherently platform-switched implants and conical emergence abutments, with a variable height of 1.5-2 mm, freeing the extension of the implant platform between 0.5-0.75 mm [Figure 5].[28] However, this mode of Platform Switching is not advisable in mandibular Implant-Mucosal support prosthesis, as reduction in abutment diameter lessens the abutment resistance in response to occlusal loading
- Using implants with a reverse conical neck [Figure 6], referred to as Bone Platform Switching.[29] This involves an inward bone ring in the coronal part of the implant that is in continuity with the alveolar bone crest. However, proximity of implant abutment junction to the alveolar crest in this design does not permit significant reduction in the crestal bone loss.

An Abutment-Implant collar diameter mismatch should be more than or equal to 0.4 mm, so as to have a significant influence on crestal bone loss, as concluded by Atieh *et al*., in their meta-analysis of their studies on Platform Switching.[30] Canuello *et al*., found that the amount of MBL was inversely proportional to the extent of the abutment-implant collar diameter mismatch.[31]

Advantages of platform switching
- It facilitates formation of a peri-implant soft tissue cuff. In natural dentition, the junctional epithelium

Figure 3: Platform-switched implant, with an abutment diameter less than the implant platform diameter

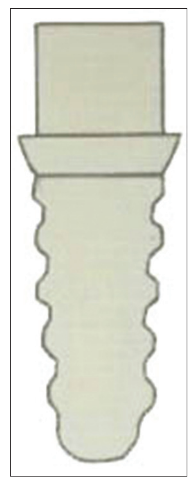

Figure 4: Expanded implant platform with equal implant and abutment diameter

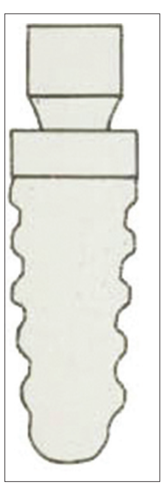

Figure 5: Inherently platform-switched implants using conical emergence abutments

Figure 6: Implant with a reverse conical neck

provides a seal at the base of the sulcus against bacterial penetration. The other line of defense present in natural dentition and absent in implants is the periodontal ligament. As no cementum or fibers are present on the surface of an implant, the infection has the potential to spread directly into the osseous structures resulting in bone loss and ultimately implant failure. Platform Switching provides a horizontal shelf for the formation of a leak-proof peri-implant soft tissue cuff, which seals the crestal bone from the oral environment and bacterial invasion

- Effect on soft tissue esthetics around the dental implants: Tarnow *et al*., showed how the presence of the dental papilla is influenced by the distance between the implants.[32] When two implants are placed close to one another (interimplant distance 3 mm or less) the inter-implant bone height can resorb below the implant-abutment connection, reducing the presence of an inter-implant papilla. This may affect the clinical result in the esthetic zone. Platform Switching reduces this physiological resorption, moving the microgap away from the inter-implant bone that supports the papilla. Maintenance of the midfacial bone height helps to maintain facial gingival tissues. This helps to avoid cosmetic deformities, phonetic problems, and lateral food impaction[33]
- Unlike Platform-Matched (PM) implants, where a high stress area around the implant's neck and along its lateral surface is present, the Platform-Switched model has the biomechanical advantage of shifting stress concentration away from the crestal bone implant interface. Shear force exerted on the cortical bone in the PS model is lower than in the PM model[19]
- Where anatomic structures such as the sinus cavity or the alveolar nerve limit the residual bone height, the Platform-Switching approach minimizes bone resorption and increases the biomechanical support available to the implant[33]
- Improved Bone Support for Short Implants: Bone remodeling around a platform-switched implant is minimized, therefore, there is potentially a greater bone/implant contact for short implants, thus opening the possibility of treating more patients with less extensive therapy
- The amount of restorative volume available for an optimally contoured, physiological implant restoration is a critical factor for the success of an implant. The crestal bone being preserved, both horizontally and vertically, with the use of platform-switched implants, support is retained for the interdental papillae. Maintenance of the midfacial bone height helps to maintain the facial gingival tissues
- Platform expansion in the immediate extraction situations makes it possible to minimize the gap between the recently extracted tooth bed and the implant, and acts as a physical barrier against the penetration of bacteria into the zone of contact between the bone and implant. Also, an increase in the diameter favors improved primary stability and formation of a new biological space.

Limitations of platform switching

- For Platform Switching to be effective, undersizing of the components must be carried out during all phases of the implant treatment, that is, from placement of the implant through to the final restoration[22]
- Sufficient prosthetic space is needed to develop a proper emergence profile[16]
- It increases the stress in abutment or the abutment screw[19]
- Platform Switching may have a positive effect on bone preservation in the first year, but after five years, the marginal bone change is insignificant, as compared to that at one year, around both PS and PM implants (Vigolo and Givani).[34]

Discussion

The selected studies for review were published in the last 10 years and their observation period ranged from 12 months to more than 10 years. Twelve studies were randomized and four were PCCS. The remaining five were clinical case series without control [Table 1]. Most of the RCTs contrasting PS and PM implants have given encouraging results, describing PS to be of key importance for crestal bone stability, whereas, two studies have not found significant differences in bone level changes in PS compared to PM. Vanderweghe *et al*. concluded that PS decreases bone loss by 30% and that PS is only effective when mucosal thickness allows establishment of biological width.[35] The strong point of this study was that their test and control group implants were in the same patient. There were only two more studies with PS and PM implants placed in the same patient. Enkling *et al*. in their split mouth trial did not find statistically significant reduction in peri-implant crestal bone loss in relation to PS implants.[36] Trammell *et al*. could also demonstrate a difference of only 0.2 mm in crestal bone loss in PS versus PM implants placed in the same patient.[37] However, inherent measurement variability in periapical radiographs has to be considered while interpreting the significance of such data.

Penarrocha-Diago *et al*. concluded in their study that difference in bone loss after a 12-month follow up was statistically significant in PS (0.12 ± 0.17) compared to PM implants (0.38 ± 0.51 mm).[38] They had used implants with a treated surface, microthreads at the neck, and internal connection in the PS group, as opposed to the machined surface, without microthreads and external connection in the PM group in 18 totally edentulous patients. Studies by Young KS, Bratu EA, and Lee SY, have shown that a rough surface with microthreads at the implant neck help to preserve the peri-implant crestal bone.[39-41] Therefore, the presence of

Table 1: Study design and observations of the reviewed studies

Author	Study design	No. of subjects No of Implants	Observations Mean MBL of platform-switched and platform-matched implants in mm
Enkling *et al.* (2013)	RCT	25 subjects 50 implants	After one year, PS=0.56±0.44, PM=0.61±0.57 After three years, PS=0.69±0.43, PM=0.74±0.57
Vanderweghe *et al.* (2012)	RCT	15 subjects 30 implants	After three months, PS=0.28, PM=0.5 After six months, PS=0.64, PM=0.05 After12 months, PS=0.66, PM=0.94
Penarrocha-Diago *et al.* (2012)	RCT	18 subjects 120 implants	After six months, PS=0.07±0.13, PM=0.27±0.43 After 12 months, PS=0.12±0.17, PM=0.38±0.51
Canullo *et al.* (2012)	RCT	40 subjects 80 implants	After 18 months, PS=0.5±0.1 , PM=1.6±0.3
Telleman (2012)	RCT	80 subjects 106 implants	After 12 months, PS=0.51±0.51, PM=0.73±0.48
Fernandez-Formosa (2012)	RCT	54 subjects 114 implants	After 12 months, PS=0.68±0.88, PM=2.23±0.22
Canullo *et al.* (2010)	RCT	31 subjects 80 implants	After, 33 months, PM=1.48±0.42 PS1=0.99±0.42, PS2=0.87±0.43, PS3=0.64±0.32 (according to variable amount of PS)
Tramell *et al.* (2009)	RCT	10 subjects 25 implants	After 24 months, PS=0.99±0.53, PM=1.19±0.58
Crespi *et al.* (2009)	RCT	45 subjects 64 implants	After 24 months, PS=0.73±0.52, PM=0.78±0.49
Canullo *et al.* (2009)	RCT	22 subjects 22 implants	After 24 months, PS=0.30±0.16, PM=1.19±0.35
Prosper *et al.* (2009)	RCT	60 subjects 360 implants	After 24 months, PS=0.05±0.23, PM=0.19±0.47
Huzeler *et al.* (2007)	RCT	15 subjects 22 implants	After 12 months, PS=0.22±0.53, PM=2.02±0.49
de Almeida *et al.* (2011)	PCCS	26 subjects 42 implants	After 33 months, PS=0.27, PM=2.30
Fickle *et al.* (2010)	PCCS	36 subjects 89 implants	After 12 months, PS=0.39±0.07, PM=1.0±0.22
Linkevicius *et al.* (2012)	PCCS	19 subjects 46 implants	A (thin mucosa) PS, M=1.61±0.24 D=1.28±0.67, PM, M=1.8±0.44 D=1.87±0.16 B (thick mucosa) PS, M=0.26±0.08 D=0.09±0.05, PM, M=1.8±0.64 D=1.87±0.16 (M=Mesial, D=Distal)
Cappiello *et al.* (2008)	PCCS	45 subjects 46 implants	After 12 months, PS=0.95±0.32, PM=1.6±0.37
Calvo-Guirado *et al.* (2014)	Clinical case series	64 subjects 86 implants	After 10 years 1.01±0.22 mm (no control gp)
Yun *et al.*(2011)	Clinical case series	27 subjects 79 implants	After 7.4 months, 0.16±0.8 (no control gp)
Wagenberg *et al.* (2010)	Clinical case series	78 subjects 94 implants	<2 mm after follow up of 11-14 years (no control gp)
Cocchetto *et al.* (2010)	Clinical case series	10 subjects 15 implants	After 18 months, 0.30 (no control gp)
Bilhan *et al.* (2010)	Clinical case series	51 subjects 126 implants	After 36 months, 0.91 (no control gp)

MBL = Marginal bone loss, RCT = Random-controlled trials, PCCS = Prospective clinical–controlled studies, PS = Platform-switched, PM = Platform-matched

microthreads only in the PS group might have had an additive effect on the crestal bone preservation. Canullo *et al*. observed significantly greater bone loss and decreased soft tissue height in the PM group as compared to the PS implants.[42] Although the surgical protocol used was the same for both groups, the external hex connection was used in the PM and inward inclined platform implants in the PS group, which could have been a confounding factor. Crespi *et al*. in their RCT, concluded that there were no differences in bone level changes between the PS and PM implants after a two-year follow up.[43] They also used different implant designs for the test and control groups, and the implants were placed in fresh extraction sockets and loaded immediately. Huzeler *et al*. also gave results in favor of PS, but their sample size was small (22 implants).[44] Fernandez-Formosa *et al*. after a follow up of 12 months reported an MBL of 0.42 mm at the PM implants and 0.01 mm at the PS implants, but they had used different healing modes (submerged/nonsubmerged).[45]

Telleman *et al*. suggested that PS reduced crestal bone resorption and better maintained the interproximal bone levels.[46] They had used a nonsubmerged healing protocol and short (8.5 mm) internal hex implants. Canullo *et al*. suggested that the extent of inward shifting was inversely proportional to the amount of marginal bone loss.[31] All implants were placed in the posterior maxilla and sinus lift surgeries had to be performed for many of them. Prosper *et al*. in their multicenter RCT, involving 360 implants, reported that the use of PS with an enlarged platform implant, as compared to the PM implant, significantly reduced MBL when placed with both the two-stage and one-stage techniques.[47] The findings over a period of 24 months indicated that the positive effect of PS was stonger when implemented on implants with an enlarged platform.

Out of the selected four PCCS, Linkevicius concluded that the initial gingival tissue thickness at the crest could be considered as a significant influence on the marginal bone stability around implants. If the tissue thickness is 2 mm or less, crestal bone loss up to 1.45 mm may occur, despite a supracrestal placement of the implant-abutment interface.[48] Fickl *et al*. observed significantly less bone loss in the PS group, but their results should be interpreted by taking into account that they had placed the PS implants crestally and the PM implants subcrestally.[49] Hammerle, Hartmann *et al*., and Pontes *et al*. had concluded that the deeper the implants were placed, the greater was the bone loss.[50-52] A histomorphometric analysis by Broggini *et al*. showed that subcrestal IAJ promoted a greater density of neutrophils and the resulting inflammation les to greater bone loss.[12] Therefore, a variation in implant placement depth can be a confounding factor. de Almeida *et al*. in their controlled clinical trial showed noticeable bone remodeling in the control group (MBL = 2.30 mm) and stable levels in the test group (MBL = 0.27 mm), but a statistical analysis to calculate the level of significance was not performed.[53] Also they had used variable placement depth of the implant shoulder in relation to the crestal bone. Cappiello *et al*. showed significant difference in bone loss with PS implants (MBL = 0.95 ± 0.32 mm) as compared to PM implants (1.67 ± 0.37 mm).[33] They had used the nonsubmerged healing mode and crestal level of implant placement.

Five clinical trials without any control group were also reviewed. Calvo-Guirado *et al*., after a follow up of 10 years reported stable PS implants, with a survival rate of 97.1% and an MBL of 1.01 ± 0.22 mm.[54] Wagenberg and Froum reported the longest follow up (11-14 years) to a prospective investigation of PS implants and confirmed the concept for crestal bone preservation.[55]

Yun *et al*. reported an MBL of 0.16 ± 0.0.08 mm (lower than previously reported values) around the PS implants, but had used implants with microthreads in the neck design, which itself was a factor for crestal bone preservation.[56] Cocchetto *et al*. reported an MBL of 0.30 mm with PS implants and Bilhan after a 36-month follow up reported an MBL of 0.91 mm.[57,58]

Baumgarten *et al*. described the platform-switching technique and its usefulness in situations where shorter implants had to be used, where implants were placed in esthetic zones, and where a larger implant was desirable, but the prosthetic space was limited.[59] Gardner described PS as an effective method to control circumferential bone loss.[16] At the same time he noted several potential disadvantages of this procedure, such as, the need for components that had similar designs and the need for enough space to develop a proper emergence profile. López-Marì *et al*., in their review on platform-switched implants, concluded that PS was capable of reducing crestal bone loss to a mean of 1.56 ± 0.7 mm; it also contributed to maintaining the width and height of the crestal bone and the crestal peak between the adjacent implants.[60] Atieh *et al*. summarized the controversial evidence on PS and concluded that the inward shift of IAJ platform switching could be considered a desirable morphological feature for crestal bone preservation, but additional, properly designed, long-term RCTs were needed, to establish long-term predictability of the concept.[30] A recent meta-analyses on PS by Strietzel *et al*. revealed a significantly less mean in the MBL of PS implants, but the studies included herein showed an unclear as well as high risk of bias and a relatively short follow-up period.[61]

Successful results in favor of PS, in the discussed studies, may be partially attributed to the various confounding factors. Most of the studies used conventional/digital radiographs to assess MBL and had the limitation of not being able to assess the buccal and lingual bone loss, as also the horizontal bone loss at the mesial/distal margins. Owing to the great heterogeneity in these studies, in their own case–control groups, in terms of implant neck geometry (smooth neck vs. rough neck with microthreads), implant abutment connection (external/internal hex/morse taper), the implant systems used (same/different manufacturers and designs), surgical protocols (submerged/nonsubmerged), placement level in relation to the crestal bone, loading protocols (immediate/delayed), and the degree of platform mismatch used, a quantitative analyses could not be performed.

Although most of the studies express a clear tendency favoring PS as an implant design modification for crestal bone preservation, long-term clinical studies with a larger sample size are still awaited.

Conclusion

Most of the authors agree that the use of implants with a modified platform (Platform Switching) improves bone crest preservation, leads to controlled biological space reposition, and holds the key to physiological prosthetic contours, with optimum esthetics. Moreover, the implant design modifications involved in Platform Switching offer multiple advantages and potential applications, for example, the anterior zone where preservation of the crestal bone can lead to improved esthetics. Due to heterogeneity in the studies available in literature, evidence in favor of PS is not definitive. Longitudinal RCTs with a larger sample size, uniform study design, implant geometry, surgical protocols, and assessment methods are needed to substantiate the predictability of

Platform Switching in preserving horizontal and vertical marginal bone levels and in improving the esthetic outcome.

References

1. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently useddental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants 1986;1:11-25.
2. Albrektsson T, Isidor F. Consensus report of session IV. In: Lang NP, Karring T, editors. Proceedings of the 1st European Workshop on Periodontology. London: Quintessence Publishing; 1994. p. 365-9.
3. Misch CE, Perel ML, Wang HL, Sammartino G, Galindo-Moreno P, Trisi P, *et al*. Implant success, survival, and failure: The InternationalCongress of Oral Implantologists (ICOI) Pisa Consensus Conference. Implant Dent 2008;17:5-15.
4. Smith DE, Zarb GA. Criteria for success of osseointegratedendosseous implants. J Prosthet Dent 1989;62:567-72.
5. Tarnow DP, Magner AW, Fletcher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. J Periodontol 1992;63:995-6.
6. Choquet V, Hermans M, Adriaenssens P, Daelemans P, Tarnow DP, Malevez C. Clinical and radiographic evaluation of the papilla level adjacent to single-tooth dental implants. A retrospective study in the maxillary anterior region. J Periodontol 2001;72:1364-71.
7. Becker W, Goldstein M, Becker BE, Sennerby L. Minimally invasive flapless implant surgery: A prospective multicenter study. Clin Implant Dent Relat Res 2005;7 Suppl 1:S21-7.
8. Kim Y, Oh TJ, Misch CE, Wang HL. Occlusal considerations in implant therapy: Clinical guidelines with biomechanical rationale. Clin Oral Implants Res 2005;16:26-35.
9. Hermann JS, Schoolfield JD, Schenk RK, Buser D, Cochran DL. Influence of the size of the microgap on crestal bone changes around titanium implants. A histometric evaluation of unloaded non-submerged implants in the canine mandible. J Periodontol 2001;72:1372-83.
10. Weng D, Nagata MJ, Bell M, Bosco AF, de Melo LG, Richter EJ. Influence of microgap location and configuration on the peri-implant bone morphology in submerged implants. An experimental study in dogs. Clin Oral Implants Res 2008;19:1141-7.
11. Myshin HL, Wiens JP. Factors affecting soft tissue around dental implants: A review of the literature. J Prosthet Dent 2005;94:440-4.
12. BrogginiN, McManus LM, Hermann JS, Medina R, Schenk RK, Buser D, *et al*. Peri-implant inflammation defined by the implant-abutment interface. J Dent Res 2006;85:473-8.
13. King GN, Hermann JS, Schoolfield JD, Buser D, Cochran DL. Influence of the size of the microgap on crestal bone levels in non-submerged dental implants: A radiographic study in the canine mandible. J Periodontol 2002;73:1111-7.
14. Abrahamsson I, Berglundh T, Lindhe J. The mucosal barrier following abutment dis/reconnection. An experimental study in dogs. J ClinPeriodontol 1997;24:568-72.
15. Hermann F, Lerner H, Palti A. Factors influencing the preservation of the peri-implant marginal bone. Implant Dent 2007;16:165-75.
16. Gardner DM. Platform switching as a means to achieving implant esthetics. N Y State Dent J 2005;71:34-7.
17. Cochran DL, Bosshardt DD, Grize L, Higginbottom FL, Jones AA, Jung RE, *et al*. Bone response to loaded implants with non-matching implant-abutment diameters in the canine mandible. J Periodontol 2009;80:609-17.
18. Jung RE, Jones AA, Higginbottom FL, Wilson TG, Schoolfield J, Buser D, *et al*. The influence of non-matching implant andabutment diameters on radiographic crestal bone levels in dogs. J Periodontol 2008;79:260-70.
19. Maeda Y, Miura J, Taki I, Sogo M. Biomechanical analysis on platform switching: Is there any biomechanical rationale? Clin Oral Implants Res 2007;18:581-4.
20. Hsu JT, Fuh LJ, Lin DJ, Shen YW, Huang HL. Bone strain and interfacial sliding analyses of platform switching and implant diameter on an immediately loaded implant: Experimental and three-dimensional finite element analyses. J Periodontol 2009;80:1125-32.
21. Tabata LF, Assunção WG, Adelino Ricardo Barão V, de Sousa EA, Gomes EA, Delben JA. Implant platform switching: Biomechanical approach using two-dimensional finite element analysis. J CraniofacSurg 2010;21:182-7.
22. Lazzara RJ, Porter SS. Platform switching: A new concept in implant dentistry for controlling postrestorativecrestal bone levels. Int J Periodontics Restorative Dent 2006;26:9-17.
23. Luongo R, Traini T, Guidone PC, Bianco G, Cocchetto R, Celletti R. Hard and soft tissue responses to the platform-switching technique. Int J Periodontics Restorative Dent 2008;28:551-7.
24. DoundoulakisJH. The abutment/implant interface and its role in retention of crestal bone a new paradigm. New York County Dental Society Dentists Quarterly Summer 2009;16:6-7.
25. Hansson S. The implant neck: Smooth or provided with retention elements. A biomechanical approach. Clin Oral Implants Res 1999;10:394-405.
26. Norton MR. Marginal bone levels at single tooth implants with a conical fixture design. The influence of surface macro-and microstructure. Clin Oral Implant Res 1998;9;91-9.
27. Hermann JS, Buser D, Schenk RK, Cochran DL. Crestal bone changes around titanium implants. A histometric evaluation of unloaded non-submerged and submerged implants in the canine mandible. J Periodontol 2000;71:1412-24.
28. Canay S, Akça K. Biomechanical aspects of bone-level diameter shifting at implant-abutment interface. Implant Dent 2009;18:239-48.
29. Carinci F, BrunelliG, Danza M. Platform switching and bone platform switching. J Oral Implantol 2009;35:245-50.
30. Atieh MA, Ibrahim HM, Atieh AH. Platform switching for marginal bone preservation around dental implants: A systematic review and meta-analysis. J Periodontol 2010;81:1350-66.
31. Canullo L, Fedele GR, Iannello G, Jepsen S. Platform switching and marginal bone-level alterations: The results of a randomized-controlled trial. Clin Oral Implants Res 2010;21:115-21.
32. Tarnow DP, Cho SC, Wallace SS. The effect of inter-implant distance on the height of inter-implant bone crest. J Periodontol 2000;71:546-9.
33. Cappiello M, Luongo R, Di Iorio D, Bugea C, Cocchetto R, Celletti R. Evaluation of peri-implant bone loss around platform-switched implants. Int J Periodontics Restorative Dent 2008;28:347-55.

34. Vigolo P, Givani A. Platform-switched restorations on wider-diameter implants: A 5-year clinical prospective study. Int J Oral Maxillofac Implants 2009;24;103-9.
35. Vandeweghe S, De Bruyn H. A within-implant comparison to evaluate the concept of platform switching: Arandomised controlled trial. Eur J Oral Implantol 2012;5:253-62.
36. Enkling N, Jöhren P, Katsoulis J, Bayer S, Jervøe-Storm PM, Mericske-Stern R, *et al*. Influence of platform switching on bone-level alterations: A three-year randomized clinical trial. J Dent Res 2013;92 Suppl 12:139S-45S.
37. Trammell K, Geurs NC, O'Neal SJ, Liu PR, Haigh SJ, McNeal S, *et al*. A prospective, randomized, controlled comparison of platform-switched and matched-abutment implants in short-span partial denture situations. Int J Periodontics Restorative Dent 2009;29:599-605.
38. Peñarrocha-Diago MA, Flichy-Fernández AJ, Alonso-GonzálezR, Peñarrocha-Oltra D, Balaguer-Martínez J, Peñarrocha-Diago M. Influence of implant neck design and implant-abutment connection type on peri-implant health. Radiological study. Clin Oral Implants Res 2012.[Epub ahead of print].
39. Shin YK, Han CH, Heo SJ, Kim S, Chun HJ. Radiographic evaluation of marginal bone level around Implants with different neck designs after 1 year. Int J Oral Maxillofac Implants 2006;21:789-94.
40. Bratu EA, Tandlich M, Shapira L. A rough surface implant neck with microthreads reduces the amount of marginal bone loss: A prospective clinical study. Clin Oral Implants Res 2009;20:827-32.
41. Lee SY, Piao CM, Koak JY, Kim SK, Kim YS, Ku Y, *et al*. A 3-year prospective radiographic evaluation of marginal bone level around different implant systems. J Oral Rehabil 2010;37:538-44.
42. Canullo L, Rosa JC, Pinto VS, Francischone CE, Götz W. Inward-inclined implant platform for the amplified platform-switching concept: 18-month follow-up report of a prospective randomized matched-pair0 controlled trial. Int J Oral Maxillofac Implants 2012;27:927-34.
43. Crespi R, Capparè P, Gherlone E. Radiographic evaluation of marginal bone levels around platform-switched and non-platform-switched implants used in an immediate loading protocol. Int J Oral Maxillofac Implants 2009;24:920-6.
44. Hürzeler M, Fickl S, Zuhr O, Wachtel HC. Peri-implant bone level around implants with platform-switched abutments: Preliminary data from a prospective study. J Oral MaxillofacSurg 2007;65 (7 Suppl 1):33-9.
45. Fernández-Formoso N, Rilo B, Mora MJ, Martínez-Silva I, Díaz-Afonso AM. Radiographic evaluation of marginal bone maintenance around tissue level implant and bone level implant: Arandomised control trial. A 1-year follow-up.J Oral Rehabil 2012;39:830-7.
46. Telleman G, Raghoebar GM, Vissink A, Meijer HJ. Impact of platform switching on inter-proximal bone levels around short implants in the posterior region; 1-year results from a randomized clinical trial. J ClinPerodontol 2012;39:688-97.
47. Prosper L, Redaelli S, Pasi M, Zarone F, Radaelli G, Gherlone EF. A randomized prospective multicenter trial evaluating the platform-switching technique for the prevention of postrestorativecrestal bone loss. Int J Oral Maxillofac Implants 2009;24:299-308.
48. Linkevicius T, Apse P, Grybauskas S, Puisys A.The influence of soft tissue thickness on crestal bone changesaroundimplants: A 1-year prospective controlled clinical trial. Int J Oral Maxillofac Implants 2009;24:712-9.
49. Fickl S, Zuhr O, Stein JM, Hürzeler MB. Peri-implant bone level around implants with platform-switched abutments. Int J Oral Maxillofac Implants 2010;25:577-81.
50. Hämmerle CH, Brägger U, Bürgin W, Lang NP. The effect of subcrestal placement of the polished surface of ITI implants on marginal soft and hard tissues. Clin Oral Implants Res 1996;7:111-9.
51. Hartman GA, Cochran DL. Initial implant position determines the magnitude of crestal bone remodeling. J Periodontol 2004;75:572-7.
52. Pontes AE, Ribeiro FS, da Silva VC, Margonar R, Piattelli A, Cirelli JA, *et al*. Clinical and radiographic changes around dental implants inserted in different levels in relation to the crestal bone, under different restoration protocols, in the dog model. J Periodontol 2008;79:486-94.
53. de Almeida FD, Carvalho AC, Fontes M, Pedrosa A, Costa R, Noleto JW, *et al*. Radiographic evaluation of marginal bone level around internal-hex implants with switched platform: A clinical case report series. Int J Oral Maxillofac Implants 2011;26:587-92.
54. Calvo-Guirado JL, Gómez-Moreno G, Delgado-Ruiz RA, Maté Sánchez de Val JE, Negri B, RamírezFernández MP. Clinical and radiographic evaluation of osseotite-expanded platform implants related to crestal bone loss: A 10-year study. Clin Oral Implants Res 2014;25:352-8.
55. Wagenberg B, Froum SJ. Prospective study of 94 platform-switched implants observed from 1992 to 2006.Int J Periodontics Restorative Dent 2010;30:9-17.
56. Yun HJ, Park JC, Yun JH, Jung UW, Kim CS, Choi SH, *et al*. A short-term clinical study of marginal bone level change around microthreaded and platform-switched implants.J Periodontal Implant Sci 2011;41:211-7.
57. Cocchetto R, Traini T, Caddeo F, Celletti R. Evaluation of hard tissue response around wider platform-switched implants. Int J Periodontics Restorative Dent 2010;30:163-71.
58. Bilhan H, Mumcu E, Erol S, Kutay O. Influence of platform-switching on marginal bone levels for implants with mandibular overdentures: A retrospective clinical study. Implant Dent 2010;19:250-8.
59. Baumgarten H, Cocchetto R, Testori T, Meltzer A, Porter S. A new implant design for crestal bone preservation: Initial observations and case report. PractProcedAaesthetDent 2005;17:735-40.
60. López-Marí L, Calvo-Guirado JL, Martín-Castellote B, Gomez-Moreno G, López-Marí M. Implant platform switching concept: An updated review. Med Oral Patol Oral Cir Bucal 2009;14:e450-4.
61. Strietzel FP, Neumann K, Hertel M. Impact of platform switching on marginal peri-implant bone-level changes. A systematic review and meta-analysis. Clin Oral Implants Res 2014. [Epub ahead of print].

How to cite this article: Singla S, Rathee M, Kumar L, Gupta M. Platform switching: A step away from the gap. Eur J Prosthodont 2015;3:1-9.

Source of Support: Nil, **Conflict of Interest:** None declared.