

Peri-implant Crestal Bone Preservation: Where do We Stand?

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ABSTRACT

The purpose of this article is to throw light on various factors that can cause peri-implant bone loss and range of solutions that can prevent the postoperative stigma of marginal bone loss. In this article main focus is given on the four specific implant designs which have proven to be successful in maintaining the peri-implant bone level that includes Laser-Lok implant collar, platform switching at implant abutment junction, conical implant abutment interface and microthreading on implant neck. This article also presents three case reports treated by these modified nonconventional implant designs with 1 year follow-up. The added features in them found to play an imperative role in maintaining the peri-implant marginal bone and soft tissue level and thereby influence the success and survival rates of implant supported prosthesis.

Keywords: Crestal bone loss, Platform switching, Microthread.

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INTRODUCTION

The face of dentistry has changed radically over past few decades because of the incessant progress made in the discipline of dental implantology. Dental implants have now evolved into mainstream dentistry as the most advanced and essential treatment modality. They have increased the options in dental treatment for patient satisfaction, and also changed the perspective with respect to the long-term successful outcomes. The practice of implant dentistry requires proficiency in all facets whether it be patient selection, treatment planning, surgery or the prosthetic element. Thus, it is not just concerned with allied science or precised surgical skills, but hugely dependent on the knowledge, acumen, clinical experience and intelligence of the clinician to choose the appropriate implant design to achieve the stable peri-implant tissue health post-operatively.

Various clinical and radiographic criteria have been established to decide the outcome of implant supported prosthesis therapy. These criteria include mobility, pain, peri-implant bone loss at implant level and suppuration and bleeding at the peri-implant soft-tissue level.¹ To achieve a

good functional and esthetic result with implant restoration, it is important to consider the biologic principles of both soft and hard tissues around an implant.¹ In this regard, the presence of good amount and quality of bone around the implant, especially the crestal bone plays a very important role.¹ Marginal bone loss not only hampers the hard tissue support to implant but can also result in loss of interdental papilla and hence can affect the esthetics by altering the gingival contour.² However, early peri-implant bone loss has been commonly observed as a consequence of physiologic bone remodeling during initial phase of healing.³ Hence, the crestal bone resorption is considered normal till certain extent. In a two piece implant system, crestal bone resorption to first coronal thread is commonly observed after abutment attachment and loading.³ After functional loading, implant averages approximately 1.5 mm of bone loss in the first year and at least 0.2 mm per year thereafter.⁴ This tendency of crestal bone to naturally adjust can affect both the function and esthetics of the implant.² Such remodeling does not found to occur as long as the implant remains completely submerged, but rather develops when an abutment is connected or when an implant is prematurely exposed to the oral environment and bacteria.

The other factors that are responsible for bone resorption include occlusal overload,³ microgap at implant-abutment interface,⁵ apical displacement of biologic width,⁶ implant neck design,⁷ micromovement of implant and prosthetic component.⁸ In general crestal bone loss makes the way for further bacterial accumulation that tends to cause secondary peri-implantitis. This process in turn can lead to occlusal overload due to loss of bone support and results in additional crestal bone loss which ultimately lead to failure of implant.³ To combat this crestal bone loss, variety of implant designs have been described in the literature⁹⁻¹³ but only few have shown promising results like Laser-Lok microtexturing,^{10,11,14-19} platform switching,^{10,20-29} conical implant abutment interface^{12,13} and microthreading on implant neck^{12,13,30-32} In this review article, focus has been converged on these time tested means with their respective case reports.

LASER-LOK MICROTTEXTURING

Laser-Lok is a dental implant surface treatment developed to create the optimal implant surface design. It includes

series of precision-engineered cell-sized channels which are laser-machined onto the dental implant collar's surface. These surface microchannels are in the form of microgrooves with specific size and depth to perform definite functions. 8 μm microchannels which are 6 μm deep, present in upper zone of implant limited epithelial cell downgrowth by inhibition of cell migration and enhanced soft tissue attachment.¹⁰ 12 μm microchannels which are 12 μm deep present in lower zone of implant inhibited the fibrous tissue growth and enhanced proliferation of osteoblastic cells. An animal study demonstrated limited epithelial downgrowth due to closer adaptation of bone to laser microtexture collar.¹¹

A 6 months old implants attached to healing abutment were harvested to evaluate both soft and hard tissue under different microscopes. Intimate contact between junctional epithelial cells and implant surface was observed under light microscopy. Supracrestal functionally oriented collagen fibers running toward microgrooves were seen below apical extent of junctional epithelium through polarized light microscopy. SEM examination showed existence of collagen fibers, whereas microcomputerized tomography demonstrated higher bone implant contact covering all threads of implant.¹⁰

According to a recent Finite Element Analysis (FEA) study, this design demonstrated reduced stress which is associated with off axis loading, that usually occur in collar area.¹⁷ Histological evaluation of 3 retrieved immediately loaded Laser-Lok implants demonstrated more stable crestal bone level after 4 months.¹⁶ In several clinical trials also Laser-Lok surface has confirmed its role in preventing crestal bone loss.^{14,15} In a prospective controlled multicenter study, Laser-Lok implants showed reduction in bone loss by 70% (1.35 mm) compared to adjacent conventional implants after 37 months of their placement and no clinical difference was noticed between mandible and maxilla.¹⁹ In a retrospective 3 years study, this design minimized bone loss up to 0.46 mm.¹⁵ A prospective overdenture study revealed their ability to reduce bone loss by 63% in both loaded and unloaded condition.¹⁴

Laser-Lok design has been incorporated even to the implant abutment. Such abutments created a biologic seal to establish superior osseointegration and supported the peri-implant health even in implants without Laser-Lok surface.¹⁷ In a comparative canine study, crestal bone levels were found to be higher with laser lok than the standard abutments, when placed on implants with grit blasted surface.¹⁸ Functionally oriented perpendicular connective tissue fibers apposed the abutment-implant surfaces of Laser-Lok rather than parallel fibers on standard abutment surface.¹⁸ Thus, laser lok microtexturing on both implant

and abutment can effectively prevent the crestal bone loss which is considered inevitable with conventional implants.

PLATFORM SWITCHING

The concept of platform switching refers to the use of abutment or a suprastructure that is smaller than the implant diameter. During 1991, wide-diameter implants were designed to use mainly in poor quality bones to achieve improved primary stability. Due to the lack of matching-diameter prosthetic components, they were restored with standard diameter prosthetic components. The long-term radiographic follow-up of such dental implants demonstrated a smaller than expected vertical change in the crestal bone height.⁹ This led to the accidental discovery of platform switched implant design and drawn the attention of implantologists due to their positive enhancement for achievement of clinical success.

Platform switching locates the implant-abutment connection microgap away from the vertical bone-to-implant contact area thus shielding the bone from the inflammatory process associated with the implant abutment junction.⁹ It also help in prevention of crestal bone resorption by shifting the stress concentration zone away from the bone-implant interface and by directing occlusal force along the axis of implant.²⁰ In a FEA, 10% reduction in the abutment diameter caused 2.04 and 6.81% lowering of Von-Mises stress following oblique and vertical loading respectively.²⁴ After bone remodeling, this design in combination with internal connection has found to exhibit minimum distortions in stress distribution, and the stress is dispersed over the entire bone-implant contact surface smoothly and uniformly.²³ In platform switching implants degree of marginal bone resorption is inversely related to the extent of implant abutment mismatch.²⁵ The reduction in the abutment diameter of about 0.45 mm on each side was found sufficient to avoid peri-implant bone loss.²¹ This crestal bone preservation potential of platform switching retained the interproximal bone peak better than conventional implant restorations and thereby facilitates soft tissues support and improvement in crown-to-implant ratio. Hence, it was indicated in situations like narrow edentulous ridge where implants need to be placed less than 3 mm apart.¹⁰

Platform switching creates a circular horizontal step over the implant shoulder which enables a horizontal extension of the biological width. This feature eliminate changes in soft tissue morphology which is usually associated with the formation of biologic width.⁸ Implants with variable degree of platform switching have revealed stable peri-implant soft tissue histologically after 4 years of restoration irrespective of the amount of radiographic bone changes which confirms

that, platform switching does not increase the peri-implant soft tissue inflammation on long run.²⁷ Hence, it can be concluded that, an implant design that incorporates the concept of platform switching is a simple and effective way of maintaining both peri-implant hard and soft tissue thus, helping to ensure a predictable treatment outcome.

CONICAL IMPLANT ABUTMENT INTERFACE

The design of an implant abutment interface affects pattern of load application on the implant-bone interface and hence the stress pattern in marginal bone.¹² The load on an implant can be divided into its vertical and horizontal components. It has been found that, the peak bone stresses resulting from vertical and horizontal load components arise at the top of the marginal bone, and that they coincide spatially. These peak stresses added together produce a risk of stress-induced crestal bone resorption. Two FEA studies have shown that, peak bone stresses resulting from an axial load arose further down in the bone with a conical implant-abutment interface hence spares the crestal bone.^{12,13} More peripheral location of the load is found to exert higher peak stress. Since, the location of load is more central in this design hence peak stress are found less in coronal region.¹² Thus, conical implant abutment interface can control the postrestorative crestal bone levels competently.

MICROTHREADS

Minute microthreads on implant neck were first introduced on the Astra Tech Implant System™ in 1992. These microthreads increase the surface area and lead to well established bone-to-implant contact.³¹ According to a FEA study, principal stresses at the bone-implant interface in microthread model were perpendicular to the lower flank of each microthread, irrespective of the loading angle whereas in smooth model, stresses were affected by the loading angle and directed obliquely to the smooth interface, resulting in higher shear stress. Therefore although peak principal stress values were higher but, the peri-implant bone volume exhibiting a high strain level was smaller around the microthread implant. Hence, microthreading at the collar of the implant provides more compressive and less shear stress³² leading to optimal occlusal load distribution, thereby counteracts marginal bone resorption and maintains the crestal bone levels.³⁰ This implant design can improve the prognosis of implant therapy by efficiently preventing crestal bone resorption and even provide long-term esthetic result. The survival rate of the implants with rough neck and microthreading (100%) is found to be higher than those with only rough neck (94.5 to 100%) or polished neck (87 to 97.7%).³⁰

CASE REPORT

After thorough evaluation of presurgical records (study cast, IOPA, CT scan, blood investigation) cases were chosen for the selected modified design implants. All surgeries were done under strict aseptic condition with appropriate surgical protocol under local anesthesia. In first case, 36 was treated with Biohorizon® implant (4.6 × 10.5 mm) which is designed with laser lok collar (Fig. 1). In case 2 Ankylos Implant® (3.5 × 11 mm) was placed in relation to 25 which is designed with platform switching (Fig. 3). In third case 46 was treated



Fig. 1: Laser-Lok implant: immediate post-implant placement

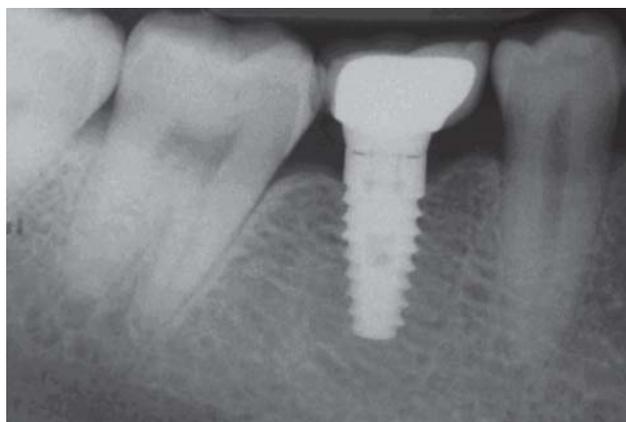


Fig. 2: Laser-Lok implant: 1 year post-prosthetic loading

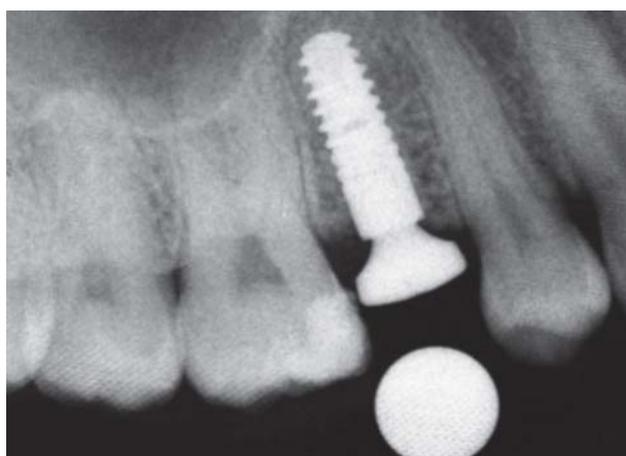


Fig. 3: Platform switched implant: immediate post-implant placement

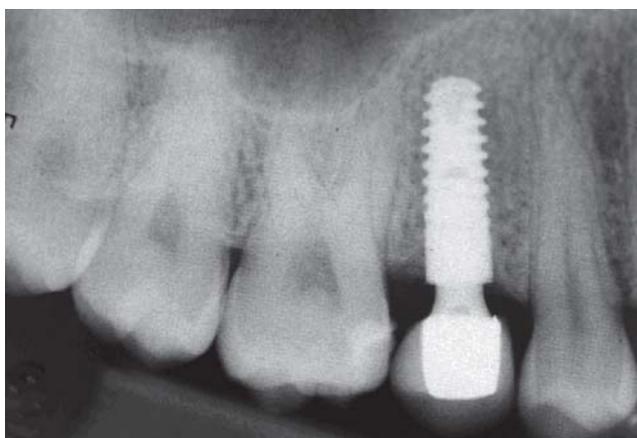


Fig. 4: Platform switched implant: 1 year post-prosthetic loading

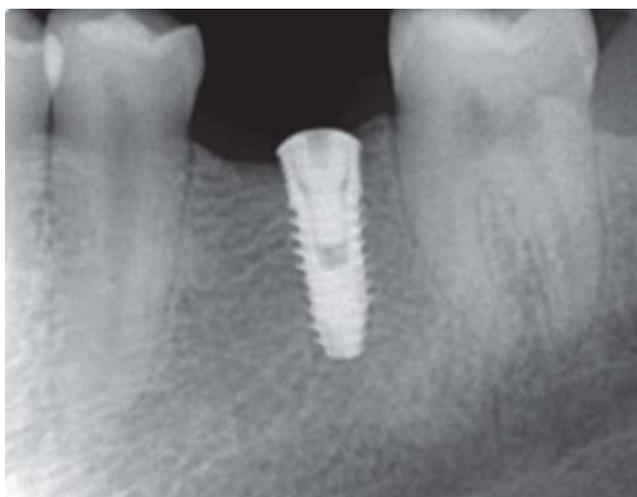


Fig. 5: Microthread implant: immediate post-implant placement



Fig. 6: Microthread implant: 1 year post-prosthetic loading

with CMI[®] implant (4 × 11.5 mm) which is designed with conical implant abutment interface and microthreading on implant collar (Fig. 5).

All three cases were loaded conventionally after a waiting period of 4 to 6 months. Cases were radiographically evaluated after 1 year of prosthetic replacement. Crestal bone level was found to be stable in all the three cases (Figs 2, 4 and 6). Cases are still under follow-up.

DISCUSSION

The longevity of a dental implant is determined by the sound integration of the peri-implant soft and hard tissues. Crestal bone loss which is considered inevitable with conventional implants can be prevented by implants with modified structural designs. So far various amendments in implant collar design have been proposed but only few of them have stood to the test of time. All 3 cases treated with the selected implant design were healed uneventfully without any complication.

Implant with Laser-Lok design was placed supracrestally by two stage protocol to obtain the benefit of microgrooves and nanostructure on upper zone of implant¹⁰ and to avoid higher risk of failure associated with one stage healing mode.³³ Laser-Lok design can be incorporated in both dental implant and abutment. It produces a biologic seal around the implant, thereby protects and maintains crestal bone health. It results in a perpendicular and functional physical attachment of implant to the bone, leading to better osseointegration. It prevents crestal bone loss by various means that includes reduced off axis loading,¹⁵ guided cell growth, minimized fibrous encapsulation, which creates healthier tissue around the implant.¹⁶ Till now Laser-Lok is the only surface treatment that has shown a true physical connective tissue attachment of implant to the bone.¹⁰

Implant with platform switch design was placed by one stage surgical protocol due to the achievement of adequate primary stability. Platform switching implants provide additional bone to implant contact and creates space for the inflammatory cells to reside without impacting the bone thus eliminating crestal bone remodeling.⁹ Although a histomorphometrical study³⁴ in dogs did not demonstrate the crucial importance of this design in maintenance of the crestal bone level, but in contrast various other studies.^{10,21-29} are in favor of this concept. Though they showed less crestal bone loss than conventional implant,¹⁰ the difference was more significant in subcrestal than crestal and supracrestal locations.²⁶ The capability of platform switching in prevention of crestal bone loss was appreciated both in threaded and smooth neck implants.²⁹ Healing mode (one/two stage) does not affect the total amount or the temporal pattern of bone loss.²⁸ Bone formation and osseointegration was also not found to be affected in both delayed and immediate loading.²²

Implant with conical implant abutment interface and microthreads on collar was placed through two stage protocol to diminish the risk of undesirable direct loading during healing.³³ Conical implant abutment interface directs stress on the bone more apically and also separates axial load component from horizontal component.^{12,13} These

factors together frees the crestal bone from detrimental effect of forces exerted and hence can save the crucial peri-implant crestal bone.¹³

Microthreads incorporated on implant collar have been confirmed to reduce crestal bone resorption.^{30,31} Its not merely the presence, but their location also plays an important role. It has been found that microthreads present on the implant top were found to have more potential in stabilizing marginal bone than those placed just below the top.³⁵ So far only one clinical trial has not shown superiority of these implants over conventional implants in maintaining crestal bone level,³⁶ but remaining literature proves their supremacy.^{17,30-32,35}

Blending of various implant designs on a single implant has also been tried and its efficiency was checked clinico-radiographically. Platform switched implant incorporated with microthreads on collar has been found to be associated with reduced marginal bone loss.³⁷ Two recent FEA studies have compared and confirmed the platform switching implant's ability in reducing stress concentration on cortical bone unlike implants incorporated with microthreads.^{38,39}

The available evidence based facts and our case reports gives us sufficient supportive reasons to represent the supremacy of these modifications beyond doubt. Hence, incorporation of these designs in implant systems will provide prolong and predictable results in implant supported prosthetic treatment.

CONCLUSION

Though the use of unique implant design is a choice of clinician, but supporting scientific literature may provide them the information regarding their indication and prognosis in a particular situation. Till now there are very limited evidences on the comparison of different implant designs individually or conjointly. Hence, further long-term, well-controlled, randomized clinical and radiographic evaluation with larger sample size is recommended to compare and correlate the existing modified implant designs to prove their superiority among themselves in achieving clinical success.

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