The Importance of Crestal Bone Preservation in the Use of Short Implants

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_It is general consensus that maintenance of bone around dental implants is one of the most important features in long-term treatment success achievement, and that progressive bone loss drastically decreases the survivability of dental implants under occlusal loading (Kitamura 2005, Horowitz 2008). Although the achievement of osseointegration after implantation is important in obtaining treatment success, it does not necessarily indicate that this bone-biomaterial interface will keep its integrity throughout the patient's life, since a large number of factors play a role on the kinetics of mineralized tissue (King 2002, Tawil 2006). Of particular interest to the private practitioner is the crestal bone loss after implantation occurring during the first year after implant placement once this loss will drastically affect the biomechanical anchorage of the prosthetic restoration and possibly jeopardize the proposed treatment (Leonard 2009).

_Factors causing crestal bone loss

This loss may be attributed to several factors including

_ excessive occlusal forces,
_ trauma during the surgical procedure,
_ inflammation/infection,
_ implant exposure during soft tissue healing,
_ implant-abutment gap present in the great majority of implant systems commercially available (bacteriological colonization),
_ early loading of a not biomechanically competent bone-biomaterial interface,
_ implant bulk device design, particularly the crest module profile.

Among the potential causes described above, many can be avoided by the clinician through proper treatment planning and patient management, while others can be evaluated/avoided through engineering concepts. It is important to note that in most cases there is not a single factor but the synergy of various causes mediating the progressive mineralized tissue loss around dental implants.

It is evident that full control of all the variables playing a role on bone loss around implants after implantation, especially around the implant crest module during the first year of implantation, is beyond any clinician's domain, once there is contribution from the biological (patient), human technical (clinician) and engineering (implant bulk design and connections) aspects to this complex problem.

Among the contributing factors that are in control of the private practitioner is a proper treatment planning to enable the right number and positioning of implants is a major issue. Once the proper number and position of implants is achieved, it facilitates proper restoration and occlusal adjustment thus diminishing to a great extent the human technical contribution to crestal bone loss (Figs. 1 and 2).

Another controllable factor is the engineering aspect of the implant system. The factors to be considered are the implant crest module and the implant-abutment connections (Tada 2003). Although there is some evidence that both design considerations play a significant role on the crestal bone loss

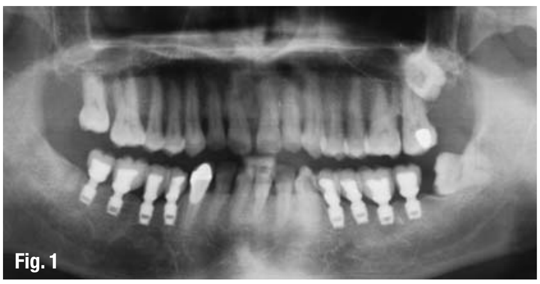

Fig. 1_ Proper treatment planning replacing the lost teeth with single crowns on short implants. Note the crest preservation over the intra-osseous Bicon Short Implants.
Fig. 2_ Missing criteria for proper treatment planning. Poor implant placement with evidence of crestal bone loss.

around implants, quantification of this processes have not been experimentally shown to date due to the multifactorial nature of the subject. The theories described in this series of articles rationalize crestal bone loss related to crest module design and implant connections (particularly the one linking the implant to its respective abutment). These theories are in qualitative agreement with clinical observations for different implant designs.

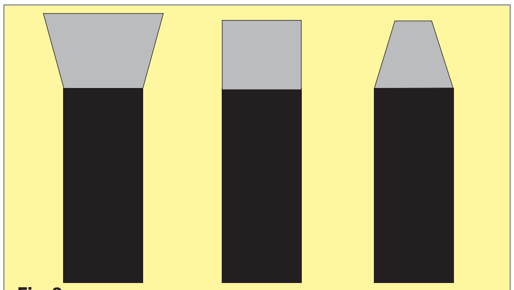

Fig. 3

Fig. 3_The three different crest module designs from left to right: "vase shaped", "cylindrical", and "rocket shaped".

_The implant crest modules biomechanics

There are currently three different basic designs of implant crest modules available in commercial scale (Bozkaya 2004). These different geometries are shown in Figure 3. Schematic representation of commercially available implant systems and their respective crest modules are presented in Figure 4. Throughout this article, the crest module which sides diverge to occlusal will be called "vase shaped" (VS), the one which sides do not diverge or converge (parallel) "cylindrical" (C), and the one which sides converge to occlusal "rocket shaped" (RS). The qualitative static mathematical analysis regarding this three different crest module designs have been previously demonstrated during the lat 80's and is mentioned in several implant dentistry textbooks (Bidez 1992).

The most desirable way to approach this type of problem is through mechanical and mathematical formulations with the aid of computer software (Finite Element Analysis), but qualitative understanding of the crest module role can be easily achieved through simple arguments on single tooth implant restorations as follows:

1) The forces that an implant is subjected during function are complex in nature due to the oblique planes comprising a crown, which make these forces oblique in nature thus resulting in vertical and horizontal force components. These vertical and horizontal force components will cause moments (force multiplied by the distance) in most instances, which may increase significantly the load which the implant is subjected. Unless the load is vertical and perfectly aligned with the implant long axis, a horizontal force component acting on the implant will always exist (Petrie 2002).

2) Consider the schematic drawing of a vase shaped, a cylindrical, and a rocket shaped implant in a bone domain as shown in Figures 5a through 5c. In these drawings, one should first note that the width of the bone domain is the same for all implant types and that these implants are inside this domain through their whole extent (the crest module is totally submerged in bone). It is also important that the implant diameters are the same (as if they were to be used to restore the same region).

It can be observed that in the cervical region of the crest module the bone amount around the module (red arrows) is smaller for the vase shaped implant than for the other two types, which leaves the vase shaped implant with a smaller amount of bone for force dissipation, showing that the bone around this crest module design is more likely to be overloaded and lost due to prosthetic occlusal function than the other two (Lemons 2004). This condition would be clinically accentuated in knife-edge ridges, where a lesser amount of bone would be present around the implant's crest module. This theory is in qualitative agreement with clinical findings where vase shaped implants present a slow but progressive bone loss after some implantation time in-vivo and rocket shaped (biomechanically more favorable) implants present none or very little bone loss as time elapses in-vivo (Venuleo 2008) (Figs. 6 to 8).

In spite of the higher amount of bone around the cervical part of the crest module of the cylindrical implant compared to the vase shaped implant, it has been shown by mathematical models which were in agreement with clinical observations have shown that there is an extensive progressive bone loss around implants presenting this geometry. This is likely due to the high interfacial shear stresses (pure shear) that these implants are subjected under vertical loading. For the other two crest module geometries, this progressive bone loss does not happen to the same extent and can be explained through simple

Fig. 4

Fig. 4a–e_Commercially available implants with different crest module designs. From left to right: Nobel Biocare (VS), ITI (VS), AstraTech (VS), Ankylos (RS) and Bicon (RS).

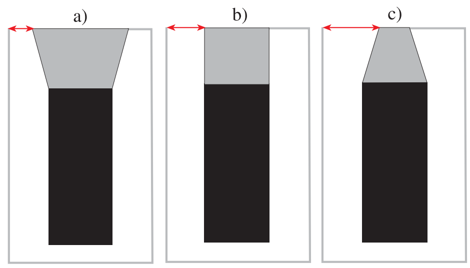

Fig. 5

Fig. 5_Implants on a bone domain of the same size. One should note the amount of bone present on the topmost part of the implant (presented by red arrows). The amount of bone around the crest module is of fundamental importance on occlusal forces distribution.

mathematical calculations where the load vector (resultant) is broken into components that are dependent on the crest module angulations, and interfacial shear stresses are attenuated when compared to cylindrical shaped crest modules. A simple representation of the reaction forces resulting from a vertical load on a vase shaped implant is shown in Figure 9 (vector magnitudes are not representative of their actual magnitude).

Further aggravation of the problem takes place as progressive bone loss occurs around the implants regardless of crest module design. As bone is lost (due to unfavorable biomechanical condition) from the upper part of the crest module downwards, implant anchorage is lost and there is an increase in load bearing of the remaining bone around the module due to an increase in the moment value (the moment increases proportionally to bone loss). This finding has been the subject of various laboratory and clinical research protocols, especially around vase shaped implants where theoretically this bone loss would evolve until catastrophic failure occurred, which is not the case. Interestingly, this bone loss usually stops at the first thread region and in most instances does not represent implant failure. In fact, these implants remain in place for long periods of time in function without any complications throughout its lifetime (Mericske-Stern 2001). This sudden stop at the first thread might be related to bacteriological contamination that may occur due to the presence of a gap on the implant-abutment connection (King 2002). Also, this phenomenon has been taken into account by several private practitioners around the world, who have changed their surgical and restorative protocols to circumvent the drawbacks of such bone loss in order to achieve better results, especially in esthetically compromised regions where the bone loss around the implant crest module makes difficult the handling of soft tissues. It has been also reported by clinicians that the microthreads present on the crest module of an implant system have significantly reduced bone loss (Figs. 10 and 11).

_Conclusion

In summary, it is widely accepted that the bone loss around implant's crest module is multidisciplinary in nature and that from an engineering perspective these are related to device design (crest module design and implant connections). From a purely mechanical standpoint, if same diameter implants with the three crest module designs available are to be placed in a given region, the rocket shaped crest module implant will be less likely to loose bone due to the higher amount of bone around its crest module, which will theoretically help dissipating the functional loads (Li Shi 2007).

It is paramount to remember that a long term preservation of the crestal bone makes the use of short implants predictable and encourage the clinician to use short implants in all kind of bone dimension and bone quality. The rocket shaped module of an sloping shoulder can be considered as the ideal implant design for a homogeneous occlusal force distribution around the implant neck/crestal bone.

In the past, it was believed that dental implants needed to be at least 10 mm in length to assure successful functioning of osseointegrated implants. However, recent studies show that short (< 10 mm) dental implants can perform well. Particularly, the plateau or fin design of dental implants with a bacterially sealed 1.5° locking-taper connection has provided for successfully functioning dental implants as short as 5.0 mm in length. Additionally, they have shown that short unsplinted dental implants had less crestal bone loss than longer splinted dental implants._

_contact implants

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Fig. 6 and 7_Cone shaped crestal bone loss around a vase shaped (left) and a cylindrical (right) implant neck after a period of loading.
Fig. 8_Note the crest preservation around the rocket shaped implant neck. The sloping shoulder guarantees a platform switching at implant level with bone growth over the neck.
Fig. 9_Decomposition of the reaction vector (dependent on the module geometry) resulting from a vertical load F applied to the implant.
Fig. 10 and 11_Comparison between a vase shaped (left) and a rocket shaped (right) implant design at crest level.


Fig. 6


Fig. 7

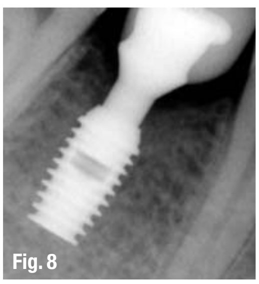


Fig. 8

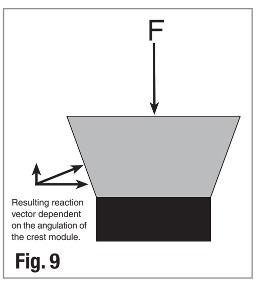


Fig. 9

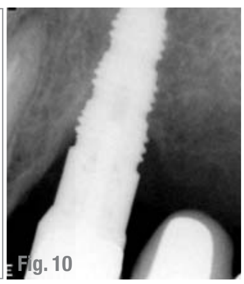
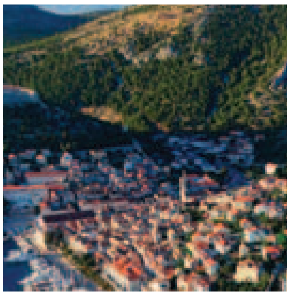
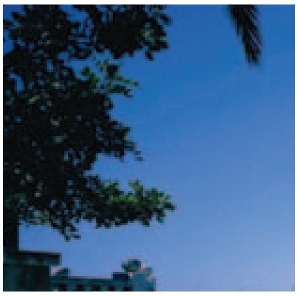
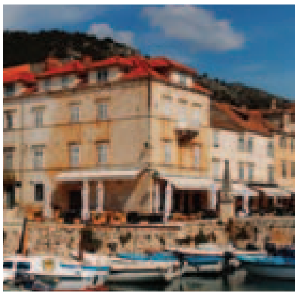
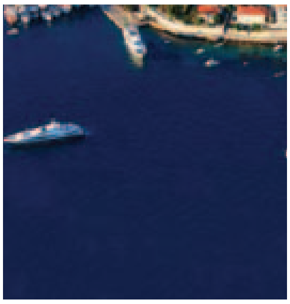
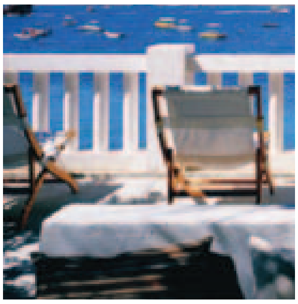
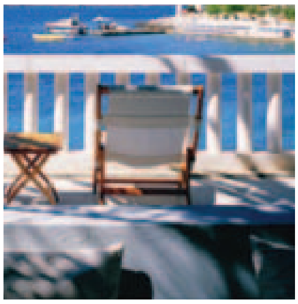


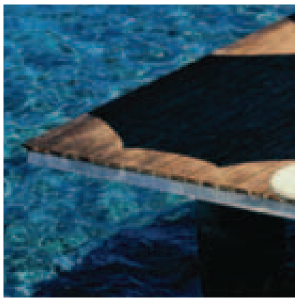
Fig. 10


Fig. 11

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From 10. to 12. of June 2010., HSK - Croatian Dental Chamber in cooperation with Oral Dent company, supported by three international associations DGZI - Deutsche Gesellschaft für Zahnärztliche Implantologie e.V., IADFE - International Academy for Dental Facial Esthetics and ESCD - European Society of Cosmetic Dentistry organizes an extraordinary assembly of experts from all over the world on the island of Hvar, Croatia.

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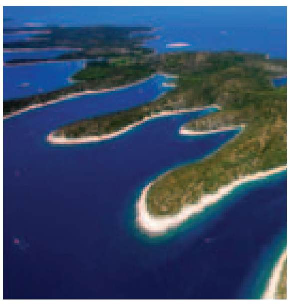


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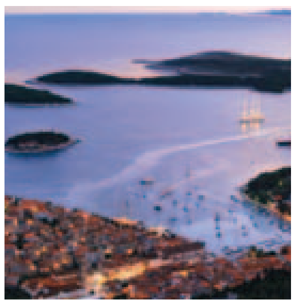

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