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MICROTHREAD CONCEPT IN DENTAL IMPLANTS

ABSTRACT

One of the most important issues affecting the success of the dental implants is to preserve the bone around the implant fixtures. There are many investigations made by researchers or manufacturing companies to ensure that the stress occurred around the implant could be distributed to the bone in most favorable manner. For this purpose macro and micro thread designs of the implants have been altered. An implant design should reduce the stress in the bone as well as should serve as a stimulant for bone regeneration. Excessive stress may cause bone resorption around the implants, on the contrary, lack of stress may lead to bone tissue atrophy around the fixtures. The collar of the implants are generally designed as not to carry loads but to reduce plaque accumulation and to transmit the forces to the implant body by acting as an interface. However, recently many authors concurred that the use of micro-threads in the neck region of the implants could be an efficient way to organize the transmitted stress through the cortical bone. Comparing with the standard threads, micro threads are accepted to increase axial stiffness of the implant and to decrease shearing stresses in the cortical bone.

Key words: Implant, Microthread, Macro design, Biomechanics

The success of dental implants can be evaluated from both aesthetical and mechanical standpoints. These two factors are closely related with achievement and maintenance of osseointegration. Macro and micro architectures such as implant design, implant-abutment joint, the presence of micro-threads, thread design and surface characteristics influence the relationship between the implant and bone and the long-term success of osseointegration.[1,2] Parallel to this, although high success rates have been reported for dental implants, technical complications related to excessive occlusal loadings and implant design are evident in the literature.[3]

It has been reported that the highest stress concentrations occur around the implant collar, in the cortical bone. Cortical bone could tolerate compressive stresses better.[4,5] Since occlusal forces are composed of vertical and horizontal components, the masticatory loads are transmitted not only vertically but also laterally. Horizontal/lateral forces may lead to bone resorption around the implants.

The loss of primer stability and bone around the implant collar after osseointegration are accepted to be the major symptoms of implant failure. Due to the forces exerted to the bone throughout the day, micro damages may occur during function and bone tissue starts remodeling to repair the damages. This is the stimulatory effect that is required for bone remodeling.

However, when the magnitude of the forces increases, bone tissue damage can increase and bone's self-repair mechanism would be insufficient to overcome this damage. Bone loss could be observed at this point.[6] Therefore an implant should be designed so as to reduce the stress in the bone around the implant and to stimulate the bone for remodelling. As excessive stresses may lead to bone resorption, absence of the stresses may also lead to bone atrophy.[7-9]

Crestal bone loss could be greatly observed within the first year of implant function and was reported to be an average of 1.2 mm vertically.[10] The soft tissue height on the crest may depend on the level of the bone.[11] It is generally accepted that presence of the crestal bone is one of the key factors for the maintenance and the appearance of the peri-implant soft tissues. Therefore preserving the crestal bone is of great importance for the functionality of implant and also for the aesthetics of the implant restoration. For instance, the alveolar bone resorption may usually be accompanied with gingival tissue recession ending up with the increased clinical crown length. This situation would lead to an increase in the intensity of lateral forces and moreover an undesirable aesthetic appearance.[11]

Modern implant dentistry manufacturers have modified the macro and micro-structures of the implants, such as implant body design, implant-abutment junction properties, thread assets, thread design and surface features to provide new clinical applications.[12,13] In many

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studies was aimed to decrease the stress levels in the cortical bone and to diminish crestal bone resorption by increasing the implant-bone contact area. For this purpose, many studies have focused on implant surface design and characteristics.

Using the two-dimensional finite element analysis, the studies revealed that micro-threaded implant model showed higher stress values in the crestal region comparing with the non-microthreaded implant.[14] Thread size can be explained by thread depth (height of the thread from implant to the top) and thread interval (from the center of the first thread to the center of next one). The use of specific thread patterns was accepted to be an efficient way to preserve the peri-implant bone level. Furthermore, the design of the implant collar could not only be influential to decrease the stress concentration but also for the stimulation of the bone to help preserving the marginal bone.[15] According to the results of finite element analysis studies, small or micro threads were found to be as effective as larger threads for the protection of the bone.[16] However, some studies pointed out that thread depth did not cause significant differences on stress distribution, however, decreased thread intervals reduced the stress concentrations.[17-19]

It has been stated that the surface characteristics have a significant influence on the marginal bone loss. A roughened implant surface could increase the resistance to shear stress in the bone-implant interface. Hansson et al. [6] have supported these findings by three-dimensional mathematical modeling and tried to determine the ideal rough surface by axisymmetric finite element analysis.

Implant collar design would generally made not for to meet the loads but to reduce the plaque accumulation and to act as an interface to transmit the loads through the implant body. However, un-roughened surface of hybrid design implants was not found to be sufficient for the distribution of occlusal loads.[20]

The results of the animal experiments and clinical follow-up studies showed that the polished implant collar surface affected the amount of bone resorption in the beginnings of implant loading periods of implant loading.[21] After the 12 months of loading period, a positive correlation was reported between the amount of bone loss and the length of un-roughened collar surface and furthermore it was detected that the bone loss extended through the first thread. Palmer et al.[22] reported that the amount of bone loss around the Astra Tech Implants (Astratech, Mölndal, Sweden) which had microthreads in the implant collar was not at significant levels. Similar results were reported by Karlsson et al[23] in a 2-year follow-up study made on 47 implants.

It was claimed that retentive parts such as surface roughness or microthreads, could make the marginal bone more resistant to the bone loss through locking force between implant surface and crestal bone.[20] In addition, several research on the crestal bone loss around the implants demonstrated that the first thread could change the shear forces occurred between the implant and crestal bone into the less destructive compressive forces. [20] In several studies it was stated that the conical implant-abutment connection could reduce the shear stresses between bone-implant connection region more compared to the connection of smooth surfaces. [24]

As the maximum stresses around the implant with microthreads were much more higher than that with a flat surface, the peri-implant bone density showed a lower strain level.[25] The structures that could increase the retention on the implant collar, such as microthreads and rough surface, have been proposed to be useful in the preservation of marginal bone.[20] Microthreads were thought to be a retention element for the stabilization of peri-implant marginal bone on the cortical bone level.[1,14,24]

While some studies claimed that certain types of implant designs (coronal collar geometry) may contribute to the bone loss, some others stated that bone loss could be prevented by the biomechanically stable connections of the collar region such as microthreads and the use of retention elements.[24,26-28] Likewise, Norton[29] reported less bone loss around the implants that had microthreads and roughened surface on collar region.

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It was reported that, after three years of functional loading of implants with microthread design, the marginal bone loss was lower than those with rough and machined surfaces. Accordingly, retention elements were said to inhibit marginal bone loss. It was observed that the differences in the design and surface configurations of the implant collar in the different implant systems could influence the amount of marginal bone loss.[30] Shin et al.[31] compared three different implant systems that had internal connection after 1 year follow-up and reported that the most effective design in terms of the protection of marginal bone during functional loading was the system that had roughened microthreads on the collar region. It is also approved by animal studies which claimed that the amount of mineralized bone around the implants that have microthreads on the collar region was in higher levels compared to implants that have no microthreads.[32,33] In a 3-year retrospective study radiographically evaluating the marginal bone change was found that rough surface with microthreads at the coronal part of implant? played an important role in the preservation of bone at the implant-bone connection region.[30]

The level of the bone around the implant collar region was found to be significantly higher in microthreaded design compared to non-microthreaded ones with flat surfaces. This result could imply the conclusion that microthreaded collar is an efficient design for the preservation of the marginal bone. Furthermore thread profile is accepted to be an important factor in the amount of stresses exerted to the bone. Microthreads with larger thread intervals could generate lesser stresses.[24] Compared with standard threads, microthreads would increase the axial stiffness of the implants and permit to lower the highest shear stresses occurred in the cortical bone.[34]

CONCLUSION

Implant success is not only successful osseointegration but also achievement of bone maintenance in long term period. Bone maintenance or preservation is both effective in biomechanics and aesthetics. Today most of the researchers agreed on retentive structures such as microthreads and roughened surfaces on the implant collar for better stress distribution and bone stimulation.

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