ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 10, pp.58701-58704, October, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

REVIEW ARTICLE

REVIEW ON IMPLANT - ABUTMENT INTERFACE

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ARTICLE INFO

Article History:
Received 22nd July, 2017
Received in revised form
14th August, 2017
Accepted 20th September, 2017
Published online 17th October, 2017

Key words:

Implant, Abutment, Interface, Connection.

ABSTRACT

The implant / abutment interface connection, is generally described as an internal or external connection. The distinctive factor that separates the two groups is the presence or absence of a geometric feature that extends above the coronal surface of the implant. The infiltration of the bacteria at implant abutment interface has been shown to depend on the type of implant-Abutment connection and their sealing capacity.This article is a review on the importance of implant – abutment interface and factors effecting the implant – abutment connection.

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Citation: Dr. Prabhu, R. and Dr. Sudheer, 2017. "Review on implant - Abutment interface", *International Journal of Current Research*, 9, (10), 58701-58704.

INTRODUCTION

Implant failures can be divided into early and late failures. Early failures are described as failures which have occurred before the abutment connection and are generally caused by inadequate Osseo Integration. Studies have shown correlation between age, gender, insertion site, fixture length, smoking and success of an implant. Late failures occur after occlusal loading of the implant and has been associated with plaque induced peri-implantitis. Since two-stage implant system are frequently used they result in a micro-gap at the implant-abutment junction, this hollow space provides a favourable site For bacterial colonization and leads to inflammatory process at implant-abutment interface. This infiltration of bacteria is a major contributory factor leading to per-implantitis (Baron *et al*., 2005). Peri-implantitis is a progressive disease of implant involving hard and soft tissues resulting in bone resorption, decreased osseointegration, pocket formation and purulence. Bone resorption may be induced by bio mechanical stress, bacteria, or a combination of both. However bacteria may be the primary factor, anaerobic bacteria have been observed growing in the micro-gap present at the implant-abutment interface and in the peri-Implant sulcus. The infiltration of the bacteria at implant abutment interface has been shown to depend on the type of implant-Abutment connection and their sealing capacity. The frequently used abutments in different implant systems are internal hexagon, external hexagon, cylinder hex, conical, octagonal, spline cam, cam tube, pin/slot.

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The hexagon design is oldest and was the most commonly used design, however it had shortcomings like screw loosening and compromised rotational and lateral stability. Therefore to overcome the shortcomings different designs of abutments were developed, out of the designs mentioned conical abutments have gained popularity as it provides mechanically sound, stable self-locking interface. Since it provides a friction lock, it minimizes the micro-gap present at implant-abutment interface. It has been suggested that conical connection reduces bacterial infiltration at implant abutment interface. The implant / abutment interface connection, is generally described as an internal or external connection. The distinctive factor that separates the two groups is the presence or absence of a geometric feature that extends above the coronal surface of the implant (Shetty *et al*., 2014). The connection can be further characterized as a slip fit joint, where a slight space exists between the mating parts and the connection is passive or, as a friction fit joint, where no space exists between the mating components and the parts are literally forced together. The joined surfaces may also incorporate a rotational resistance and indexing feature and / or lateral stabilizing geometry. This geometry is further described as octagonal, hexagonal, cone screw, cone hex, cylinder hex.

History

Parlk *et al*stated that dental implants are potentially subject to failure in the screw connection areas of an implant system, which can occur due to screw loosening or fracture (Park *et al*., 2008). Binon *et al* reported that the instability between the components of an implant system may cause not only frequent screw loosening and chronic fracture of the screws but can also cause the accumulation of plaque, an unfavourable soft tissue response, and the failure of osseointegration (Kano *et al*., 2007). Carr *et al*. and Byren *et al*. reported that the fitting of the implant-abutment interface is important for obtaining joint stability of the implant system. Moreover, under such conditions, the preload also reaches the maximum value (Coelho *et al*., 2007). McGlumphy *et al*. reported that the ideal preload is 75 % of the maximum torque causing screw fracture.

Abutment designs

Within the same basic setup, manufacturers have developed various implant–abutment connection designs. These interface designs can be roughly divided into two groups.

1. The first group may be described as butt joints or slip fit joints, with a passive connection and a slight space between implant and abutment.
2. The second group comprises conical interface designs with friction fit joints (Dittmer *et al*., 2011).

Both types can be subclassified into internal and external connection types. With the internal connection type, connective parts of the abutment are placed into the implant body. In contrast, an external connection type is observed when connective parts of the abutment enclose an extension of the implant body. The different implant–abutment connection designs can also be classified with respect to the lock against rotation by an index at the implant–abutment interface. An index is useful in transferring the model cast situation to the in vivo situation by avoiding displacement and rotation of abutment in the fixture. Norton compared the indexed internal conical interface connection of the Astra Tech (AST) system with Branemark'shexindexed butt joint connection and found that the internal conical interface exhibited increased resistance to bending moments at the fixture/abutment interface. Mollersten *et al* also investigated various implant systems with different joint designs and reported that deep joints exhibited better load bearing capacity than connections with a relatively short overlap of implant and abutment

Implant-abutment interface-the microbial link

Two piece implant system consists of the endostealpart (implant) which is placed during the first surgical phase and the mucosal part (abutment) which is attached after osseointegration. Screwing the abutment to the implant results in gap between the two components. It has been reported that this micro-gap measures around 40-60µm, due to this gap there is micro -movement during function which in turn enhances microbial leakage (Rompen *et al*., 2006). Presence of gap near the alveolar crest is also responsible for 1mm of bone loss during the first year of functional loading.The colonization of the bacteria at the implant -abutment interface depends on factors like the precision at the implant-abutment interface of different implant system and their marginal fit, the closing torque values also alters the sealing ability of the abutments. To demonstrate the microbial leakage at implant-abutment interface an in vitro study was carried out on implant - abutment assemblies using blood serum media inoculated with micro-organism. The serum was incubated in anaerobic condition for 7 days with the implants partially and completely immersed in it. The micro-organisms from the implants were collected and incubated in blood agar plates in anaerobic conditions. The result of this study showed presence of micro-organisms in both the assemblies indicating bacterial leakage. Bacterial leakage have also been observed after functional loading of implants, it has been shown that chewing reduces component stability which favours bacterial colonization at the micro-gap (Lakha *et al*., 2015). When the implants are subjected to functional loads there is exchange of fluids between internal and external environment which increases the bacterial infiltration at the peri-implant area. Therefore implant -abutment interface plays a vital role in bacterial colonization, different connections have been compared to evaluate their stability under loading conditions. Comparison between internal and external abutment connections of different implants systems have demonstrated that internal connections provide better marginal fit at the interface, thus minimizing the microbial leakage. In vivo and in vitro studies have demonstrated that among various connections used, Morse taper connections achieved higher seal as it has frictional lock system and thus reduced the bacterial infiltration at the implant-abutment interface (Aloise *et al*., 2010). Also conical abutments showed superiority in terms of torque maintenance and abutment stability which in turn minimized the bacterial colonization. Though externalhexag on are one of the oldest and commonly used abutment connections, they are considered to beineffiecient in preventing microbial leakage at the implant-abutment interface.

Importance of implant abutment interface

The Implant abutment interface determines the joint strength, stability and lateral and rotational stability (Michalakis *et al*., 2014).

The misfit between the implant and abutment causes the;

- Abutment overload
- Screw loosening /fracture
- Incorrect transmission of force to implant and marginal bone
- Microbial proliferation

Microbial proliferation causes ;

Perimucositis- a reversible inflammation of the soft tissues surrounding functional implants. Peri-implantitis- an inflammatory reaction with the loss of supporting bone in the tissues surrounding a functional implant. Finally the microbial proliferation leads to crestal bone loss (Norowski and Bumgardner, 2009).

Factors effecting the implant abutment interface

The structural integrity and biologic compatibility of the implant abutment interface and thereby that ofthe implant prosthesis depends on the following factors (Sarfaraz *et al*., 2013).

1. Implant abutment interface geometry/design
2. Micromotion
3. Screw mechanics
4. Platform switching

1. Implant abutment interface geometry/design

The original Brånemark protocol required several externally hexed implants to restore fully edentulous arches, linking them together via a metal bar with a fixed prosthesis. Dr. Gerald A Niznick was the first one to suggest modification to the Implant abutment design in the form of internal hex. In internal hex connection the mating components are situated inside the implant body which was believed to help in better stress distribution and provide better and more prosthetic options. Almost all vitro studies, with the exception of one, have demonstrated that internal connections have greater stability than external hex connections. The next major advancement in terms of geometry of the connection was the introduction of tapered connections. Tapered connections are believed to give better marginal seal and reduce the micro movements between the implant and the abutment. A conical implant-abutment interface at the level of the marginal bone is also believed to improve the distribution of the load into the supporting bone. But titanium conical abutments appear to have poorer load fatigue performance compared with external-hexagon connections. In reduced-diameter conical connections, the neck of this implant is a potential zone for fracture when subjected to high bending forces. The joined surfaces may also incorporate a rotational resistance and indexing feature and/or lateral stabilizing geometry. This geometry is further described as octagonal, hexagonal, cone screw, cone hex, cylinder hex, cam tube, and pin/slot. Combination of morse taper with other features such as internal hex is also being tried in newer implant systems. Some screw less implant systems which rely entirely on the friction fit for their stability are also available – Eg: Bicon.

2. Microgap and micromotion

Three main factors have been identified as possible causes for the formation of microgaps: occlusal load during physio-logical function, manufacturing tolerance and micromotion between the implant–abutment connection. Different types of abutment connections have been reported to produce different magnitudes of micromotion. Two major types of abutment connections are the conical and the butt-joint, the latter type of connection being available in at least three different forms: hexagonal, octagonal and trilobe. The design configuration of the abutment connection also plays a vital role in uniformly transferring occlusal stresses to the bone, thus eliminating potential microgap formation due to uneven loading. The sharp angles and vertices at abutment connections induce high stresses, causing wear, and therefore causing microgap formation. Micromotion and stress are believed to play pivotal roles in microgap formation and microbial leakage (Patil *et al*., 2013). Different designs of implant–abutment connections are predicted to induce different patterns of micromotion and stress distribution under occlusal loading.

3. Screw mechanics

McGlumphy *et al* defined the screw joint as 2 parts tightened together by a screw, such as an abutment and implant being held together by a screw. A screw is tightened by applying torque. The applied torque develops a force within the screw called the pre-load. As a screw is tightened, it elongates, producing tension. Elastic recovery of the screw pulls the 2 parts together, creating a clamping force. The preload in the screw, from elongation and elastic recovery, is equal in magnitude to the clamping force.Opposing the clamping force is a joint separating force, which attempts to separate the screw joint. Screw loosening occurs when the joint-separating forces acting on the screw joint are greater than the clamping forces holding the screw unit together. Excessive forces cause slippage between threads of the screw and threads of the bore, resulting in a loss of preload. When the clinician applies a torque to a screw to tighten its components together, the tightening torque creates a preload in the screw. The preload is determined by the applied torque and other factors, such as the screw alloy, screw head design, and abutment surface. The established preload is proportional to the applied torque. The torque value can be controlled by the clinician and can be reproduced from implant prosthesis to implant prosthesis.Too little torque may allow separation of the joint and result in screw fatigue, loosening, and failure. Too large a torque may strip the screw threads. Increasing the torque will increase the preload. Increasing the preload maximizes the stability of the screw joint by increasing the clamping threshold that separating forces must overcome to cause screw loosening. The amount of torque than can be applied is limited by the ultimate strength of the screw. McGlumphy *et al* have stated that the optimal torque value is 75% of the torque needed to cause screw failure.

Platform switching

The concept of "platform switching" refers to the use of a smaller-diameter abutment on a larger-diameter implant collar. This connection shifts the perimeter of the implant–abutment junction (IAJ) inward toward the central axis (i.e. the middle) of the implant. Platform switching is a method of preventing crestal bone loss. Although this feature is offered by internal and external connections, the internal connection design uses platform switching more often. To platform switch, the diameter of the abutment is narrower than that of the implant (Lazzara and Porter, 2006).

Benefits of platform switching

1. Increased implant longevity.
2. Improved esthetics as crestal bone preservation helps preserve papilla.
3. The effect of inter-implant distance is minimized. A minimum of 3 mm inter-implant distance is needed to preserve marginal bone. Arthur *et al*, found that distances of 1, 2 and 3 mm between implants do not result in statistically significant differences in crestal bone loss around submerged or non-submerged implants with a Morse cone connection and platform switching.

The only requirement of platform-switched implant is that the implant should be placed crestally if sufficient soft tissue height and inter-occlusal space are present, or sub-crestally if insufficient soft tissue height and inter-occlusal space are present. So, soft tissue depth of approximately 3 mm should be present to place platform-switched implants or else bone resorption is likely to occur, irrespective of implant geometry. Also, sufficient bone width should be present to accommodate the larger-diameter implant.

Limitations of platform switching

1. If normal size abutments are to be used, larger size implants need to be placed. This is not possible every time clinically, especially if bone width is less.
2. If normal sized implants are placed, smaller-diameter abutments are necessary, which may compromise the emergence profile, especially in anterior cases.

Conclusion

The stability of the joint in the implant abutment interface is critical and needs appropriate attention.Existence of such micro-gap may hamper the life of implant prosthesis. Reducing this micro-gap to an acceptable level should be the one of the set goal for a implant restoration.

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