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The Microbial Neck: A Biological Review of the Various Implant: Abutment Connections

Pronoy Mukhopadhyay*, Arun Khalikar, Sattyam Wankhade, Suryakant Deogade

Department of Prosthodontics, Government Dental College and Hospital, Nagpur, Maharashtra, India

ABSTRACT

Longevity of an implant-supported prosthesis bases its core principles on the biological stability of the implant itself. A seal maintained against microbial infiltration is supposed to maintain this stability and ensure a relative constancy in the peri-implant crestal bone levels. But, in the oral environment this hermetic seal is difficult to achieve given the lack of a pristine niche for these implants. This study reviews the importance of selecting implant systems with connection designs that optimize the seal and ensure better long-term prognosis of the prosthesis, thus placed. For an accurate review, an electronic search of the PubMed database was done using keywords to review studies that compare the crestal bone levels and microleakage around various implant-abutment connection designs. Based on the studies reviewed, the conical connection design proved to be the most biologically stable junctional geometry due to the better microbial seal and the lesser micromovement observed in these types of implants during functional loading. Moreover, this review even emphasizes the need for more longitudinal clinical trials to evaluate the microbial seal of these connection designs within the actual oral environment to evaluate long-term changes in the peri-implant tissues and subsequently, thus even factor the prognosis of the planned prosthetic intervention.

Keywords:

Implant-Abutment Connection, Peri-Implant Bone Loss, Crestal Bone Loss, Microleakage.

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Pronoy Mukhopadhyay, Arun Khalikar, Sattyam Wankhade, Suryakant Deogade

Corresponding author: Pronoy Mukhopadhyay
e-mail✉:pronoy.mukherjee@yahoo.com
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INTRODUCTION

During the last decade, implantology has become an indispensable part of mainstream dentistry, helping dentists to improve the quality of life of large patient populations. While implant treatment could often be a convenient alternative to conventional treatment options, in certain cases, it is the treatment of first choice for the rehabilitation of severe functional, anatomical or aesthetic problems arising from lost tooth/teeth. Implant-Abutment connection is the point of contact between the surgical and prosthetic phase and is required to provide adequate joint strength, rotational stability, prosthetic indexing, and resistance to microbial penetration. [1] Over the years, different connection designs (see Table 1) have been developed with an aim to reduce stress on the prosthetic component and on bone-implant interface and provide adequate prosthetic stability. The implant/abutment connection, by convention, is generally described as an internal or external connection [2]. These two implant-abutment connections can be distinguished by whether or not there exists an extension of a geometric figure above the body of the implant. In external connection implants, we observe a distinct projection external to the body of the implant, whereas in internal connection implants the implant-abutment connection is recessed into the body of the implant. 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 forced into place. [3] The mating surfaces are further characterized as being a butt joint, which consists of two right-angled flat surfaces contacting one another, or a bevel joint, where the surfaces are angled either internally or externally. 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, conical, cylinder hex and spline [2]. A microgap at the implant-abutment interface allows micro-organisms to proliferate close to the epithelial attachment, which often results in bone resorption approximately 2 mm apical to the microgap. Since two- stage implant systems are frequently used, they result in a micro-gap at the implant-abutment junction, this hollow space provides a favourable niche for bacterial colonization and leads to inflammatory process at implant-abutment interface. This infiltration of bacteria is a major contributory factor leading to peri-implantitis. 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 reviews the influence of Implant-Abutment connection type on the peri-implant crestal bone loss values and Microbial leakage across the connection. The correlation between micro-leakage and crestal bone loss further elucidates the role of the integrity of the connection on the peri-implant inflammatory status and long-term biological stability of implants of different connection types.

MATERIAL AND METHODS

An electronic search was done for English language articles from 2011 to January 2021 in the databases of PubMed/ MedLine. The search strategy involved an initial preliminary search for the effect of Implant-Abutment Connection design on the biological stability of the implants using MeSH keywords "dental implant OR abutment OR connection AND microleakage OR bone loss". Titles and abstracts were searched upon to accurately relate the comparison of different connection designs based on two distinct parameters- Peri-implant Crestal Bone Loss and Microleakage/Bacterial leakage along the External, Internal and Morse taper connections. The type of studies involved were studies done on/ involving humans only, randomized controlled trials, in-vitro studies and systematic reviews. The search for microleakage finally yielded a total of 9 completely accessible articles under review while for peri-implant crestal bone loss yielded a total of 3 conclusive articles.

THE MICROBIAL INTERFACE

Two-piece implant system consists of the endosteal part (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 a gap between the two components.[7] 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. Presence of gap near the alveolar crest is also responsible for 1mm of bone loss during the first year of functional loading. Microbial penetration through the micro-gap invariably exists at the implant-abutment interface. Type of connection used is one of the important factors influencing bacterial adhesion, however other factors should also be given prime importance when implants are used. Factors such as surface roughness of implants, the amount of torque used, the variability or the changing oral micro flora has to be considered.[9] To demonstrate the microbial leakage at implant-abutment interface, an in vitro study by Piattelli et al 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. [10] Though conical connections have shown a better sealing ability, micro-gap invariably exists at the interface, therefore it can be stated that no connection has completely eliminated the micro-gap formation or has led to a sterile environment inside the implant connection.

PERI-IMPLANT CRESTAL BONE LOSS

The long-term success of endosseous implants depends mainly on the preservation of bone support. Indeed, maintenance of osseointegration and stability in marginal bone level are imperative to this success. Peri-implant marginal bone loss is influenced by many factors and by multiple phenomena. Those might include the surgical technique, implant positioning, tissue thickness, the presence of a micro-gap at the implant-abutment interface, and the implant design. All of them can also influence the stability of the marginal bone crest. The criteria to define success in implant dentistry are under constant debate, but the achievement and maintenance of osseointegration are recognized as crucial factors, and Marginal Bone Loss (MBL) is therefore a key consideration.

The ubiquitous loss of up to 2 mm of bone around implant neck during the first year after functional loading has widely been considered acceptable by the dental community and has even been considered a successful outcome in some classifications and consensus statements. However, tissue stability is expected at one year after placement, and a loss of more than 0.2 mm per year is regarded as undesirable. Other Authors have claimed that a marginal bone loss of 1.5 mm in the first year, 1.8 mm, or 1.5– 2 mm represents a good outcome. A marginal bone loss of less than three threads has also been proposed as a successful criterion, despite the variability in inter-thread distances among different implant systems. A design strategy including the connection of a smaller-diameter abutment relative to the platform diameter of the titanium implant (referred to as platform-switching) was proven to reduce the epithelial component of the biological width, thus resulting in a preservation of crestal bone levels in both animals and humans. In addition, the implant–abutment connection, the size of the machined neck, the size of the micro gap at the implant–abutment interface, and its insertion relative to the alveolar crest may contribute to physiological bone remodeling after implant placement.

Microbial review of various connection designs-microleakage/sealing capability:

Performed in vitro study to evaluate bacterial leakage from human saliva to the internal part of the implants along the implant-abutment interface under loaded and unloaded conditions using DNA Checkerboard in internal hex, external hex and Morse tapered implants. In their study, the Morse cone connection presented the lowest count of microorganisms in both the unloaded and loaded groups. Loaded implants presented with higher counts of microorganisms than unloaded implants for external- and internal-hex connections evaluated, *in vitro*, the leakage observed in internal hexagon and Morse taper implant-abutment connections through bacterial suspension technique to observe turbidity in the reactive broth. They concluded the Morse taper connection showed significantly lesser microbial leakage along the junctional interface. in used external connection implant and conical internal connection (Morse taper) implants in their study. The results of the study showed that less microleakage was shown by Morse taper connection implants them external connection implants. A gap of 10 µm was presented by external connection implant which was more than Morse taper implants with gap of 2-3 µm. When 30 Ncm torque was applied to tighten the abutments, there was decrease in microleakage. A possible reason for this, was creation of perfect seal at external connections and there was friction locking at the connection of Morse taper implants. Morse taper implant-abutment connection has a unique design with an internal joint design between two conical structures. The internally tapered design creates high propensity of parallelism between the two structures within the joint space and provides significant amount of friction. Evaluated microleakage of internal Morse-taper connection and found that there was minimal penetration of bacteria down to the Implant-Abutment Interface. Dynamic loading increases the penetration of bacteria as there was micro movement at the interface, which causes a pumping effect and leads to detrimental effects on the marginal bone stability conducted a five year follow up study on humans for different implant connections under functional loading. Results showed that microbial contamination was seen in all the connections. Internal Hex and conical connection implant showed less leakage of bacteria at the peri-implant sulcus and inside the connection than external hexagon implants. in 2016, in their study tested both conventional flat-head and conical-head abutment screws, in External Hex and Trichannel Internal platform (TI) implants, under unloaded condition with 38 microbial species. In both the connections, large number of microbial species penetrated at Implant-Abutment Interface. Implants attached with conical head abutment screws showed fewer microorganisms in comparison to conventional flat-head screws in 2017, in their systematic review concluded that external hexagon implants failed completely to prevent microleakage in both static and dynamic loading conditions of implants. Internal hexagon implants mainly internal conical (Morse taper) implants are very promising in case of static loading and showed less microleakage in dynamic loading conditions. They also suggested that the torque recommended by manufacturer should be followed strictly to get a better seal at abutment-implant interface. Compared microleakage across external hex and morse-taper implants in loaded and unloaded conditions using dye-penetration tests in an in-vitro environment and concluded the Morse Taper connection to have superior microbial seal along the implant-abutment junction in 2018 conducted an in-vitro study comparing external, internal parallel and internal conical connection for micro-leakage using a dye-penetration model. They concluded that the Conical Connection was stable even after the loading in the Reverse Torque Values of abutment screw and it prevented microleakage from the microgap between the implant body and the abutment, among the three tested connections.

Review comparing peri-implant crestal bone loss amongst various connection designs

In a prospective clinical study, in 2012 compared epicrestally inserted root-form implants (acid-etched surface, microthreads in the neck area, length: 8.5–13 mm, outer diameter 4.3 mm) exhibiting either an external or internal implant–abutment connection. Radiographic evaluation after 1 year revealed significantly higher mean Crestal Bone Loss values for the external, when compared with the internal–abutment connection conducted a study which showed that the crestal bone change in 1st 6 months after loading were all within the success criteria proposed by i. e. bone loss<1.5 mm in the first year. The mean changes were less than 1mm in first year for all implants. Crestal bone loss did not differ significantly. Slightly greater—60% for external hex and 52% for both internal octagon and internal Morse taperduring the healing phase (before occlusal loading) than during loading phases 1 and 2 (3 and 6 months after occlusal loading, respectively). In a systematic review conducted by Caricasulo et al. in 2018 concluded peri-implant Bone Loss is generally lower in the short-medium term when internal types of interface are adopted. In particular, conical connections seem to be more advantageous, guaranteeing better seal performances and stability of the implant-abutment interface, but this fact is validated especially by in vitro studies or in vivo works with a follow-up.

CONCLUSION

On the evidence perspective, the influence of implant-abutment connection type on the peri-implant bone loss needs to be further substantiated by more controlled human trials over a longitudinal basis. We have reviewed the various connections available and their influence on the above-mentioned aspects and may unanimously conclude the Friction-fit tapered connection to be of biomechanical superiority followed by the internal and the external connections in a descending order, respectively. The homogeneity of the systematic reviews conducted over the years, have also upheld the Morse taper concept to be amongst the more acceptable connection on all perspectives. The fact that these results correlate with the excellent sealing capabilities of the conical connection, bring about a positive correlation between the chances of peri-implant disease in connections with poor peri-implant seal ability.

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