Review Article

DOI: 10.7860/JCDR/2017/28951.10054

Dentistry Section

# Microleakage at the Different Implant Abutment Interface: A Systematic Review

SUNIL KUMAR MISHRA[1], RAMESH CHOWDHARY[2], SHAIL KUMARI[3]

## ABSTRACT

**Introduction:** Presence of gap at the implant-abutment interface, leads to microleakage and accumulation of bacteria which can affect the success of dental implants.

**Aim:** To evaluate the sealing capability of different implant connections against microleakage.

**Materials and Methods:** In January 2017 an electronic search of literature was performed, in Medline, EBSCO host and Pubmed data base. The search was focused on ability of different implant connections in preventing microleakage. The related titles and abstracts available in English were screened, and the articles that fulfilled the inclusion criteria were selected for full text reading.

**Results:** In this systematic review, literature search initially resulted in 78 articles among which 30 articles only fulfilled the criteria for inclusion and were finally included in the review. Almost all the studies showed that there was some amount of microleakage at abutment implant interface. Microleakage was very less in Morse taper implants in comparison to other implant connections. Majority of studies showed less microleakage in static loading conditions and microleakage increases in dynamic loading conditions.

**Conclusion:** External hexagon implants failed completely to prevent microleakage in both static and dynamic loading conditions of implants. Morse taper implants were very promising in case of static loading and also showed less microleakage in dynamic loading conditions. Torque recommended by manufacturer should be followed strictly and zirconia abutments were more prone to microleakage than titanium abutments and should be avoided.

**Keywords:** Bacterial leakage, Dental implant, Dynamic loading, Torque

## INTRODUCTION

From past 35 years implants are considered as most successful treatment option for the restoration of missing teeth [1]. Implant systems commonly consist of an endosteal fixture, which is osseointegrated in the bone and an abutment supporting the prosthesis which is connected with a screw to the fixture. Two staged implant procedure minimizes the early exposure of implant to stress and thus helps in obtaining successful osseointegration. The Implant Abutment Interface (IAI) has external or internal connection. Today implants with internal connection are more commonly manufactured and marketed [2,3].

The misfit of IAI in two piece implant systems results in colonization of bacteria at the interface and is a major challenge for the success of implant. Accumulation of microbes around the implants may lead to infections of peri-implant soft tissues and may cause bone loss around the implant which leads to failure of dental implant [4]. From past many years due to better mechanical properties and good biocompatibility, dental implants and their abutments are mainly made of commercially pure titanium. In patients with thin and translucent soft tissue, the bluish hue of titanium abutments presents an unnatural appearance [5]. Manufacturers of dental implants have made different types of abutment, implant platforms, thread design in an attempt to improve the properties and performance of implants [6]. In oral rehabilitation of a patient in whom aesthetics is a critical issue, the prosthesis on titanium abutment creates a major challenge for the clinician. In such compromised cases ceramic abutments have become available for better aesthetics and acceptance to the patients. Bacterial leakage in ceramic abutment is not very clear as data available is very scare [7,8].

This systematic review was done to evaluate the sealing capability of different implant connections against microleakage. The effect of different loading conditions on microleakage of implant and also the torque used to seal implant-abutment and their role in preventing microleakage was studied.

## MATERIALS AND METHODS

### Search Strategy

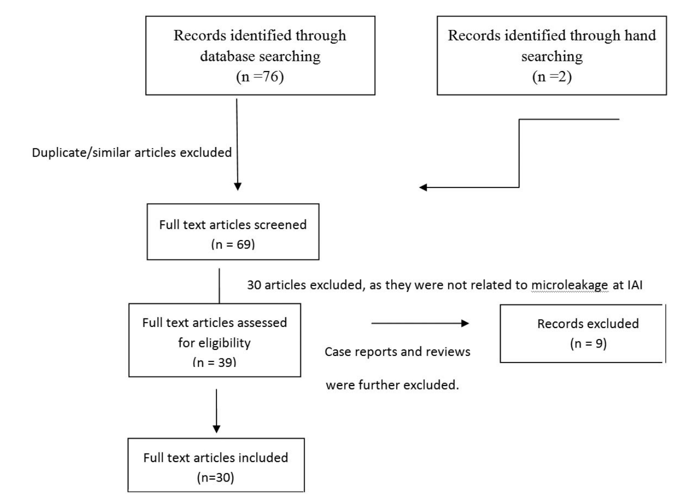
Dental literature in Medline, EBSCO host and Pubmed databases was searched from the year January 2012 to December 2016. The literature search was limited to peer-reviewed journals available in English. The key words searched for this review were microleakage, abutment, dental implants, interface and bacterial leakage. A combination of the following terms was searched: bacterial leakage at implant abutment interface, microleakage and abutment implant interface, microleakage in dental implants, microleakage at abutment implant interface, dental implant and microleakage. A manual as well as electronic search was done to select the relevant articles.

### Selection Criteria

The systematic screening of the article was done and a flow chart [Table/Fig-1] was provided for reference. In the present systematic review the following inclusion criteria was followed to determine which articles to be included for review. Articles published or accepted in between January 2012 to December 2016 were only included. Articles related to the different implant connections and resistance to microleakage was selected. The abstracts and full text articles of in vitro and human studies published in English were included. Review articles and case reports were excluded. Literature search initially resulted in 78 articles among which 30 articles which fulfilled the criteria for inclusion were included in the review [Table/Fig-2] [1,2,9-36].

## RESULTS

A brief summary of the in vitro and human studies presenting microleakage at different implant-abutment connections, under unloaded, static or dynamic loading conditions at different torque




**[Table/Fig-1]:** Flow chart presented the screening of articles related to the different implant connections and resistance to microleakage to be included in the review.

values was tabulated in [Table/Fig-2]. Out of 30 articles selected, 10 studies were done with dynamic loading ranging from 16000 cycles to 1200000 cycles [2,11,14,15,21,25,27,28,32,36] and rest were either unloaded or done under static loading conditions [1,9,10,12,13,16-20,22-24,26,29-31,33-35]. The follow up of studies ranged from five minutes to five years. Twenty six studies were done using microorganisms [1,2-10,12,13,15,16,18,20-36], two using dyes [11,19], one with de-ionized water [17] and one with acrylic resin [14]. The torque used in various studies ranged from 15 Ncm to 35 Ncm. The implants used in different studies ranges from three implants to 150 implants. Out of 30 studies there was only one study which was done on humans with a follow up of five years [22]. Almost all the studies showed that there was some amount of microleakage at abutment implant interface. Microleakage was very less in Morse taper implants in comparison to other implant connections. Many studies showed less microleakage in static loading conditions and microleakage increased in dynamic loading conditions.

| Author/ Year/ Type of study | Implant system/ Number of implants (n) | Type of implant connection | Torque used/ Cyclic loading (Ncm) | Follow up | Bacteria /Dye used | Type of micro leakage analyzed | Method of evaluation | Outcome of the study |
|---|---|---|---|---|---|---|---|---|
| Do Nascimento et al., [9] In vitro | Revolution Implant; SIN / n=30 | External hexagon | 32 Ncm/ Non loaded | 7 days | 13 bacterial species | IAI | DNA Checkerboard/ Culture | Commonly C. gingivalis and S.mutans were found to harbour the internal surface of the implants. |
| Harder S et al., [10] In vitro | Cone-log implants; Straumann Implant/n=20 | Conical implant abutment connection | Recommended by manufacturer/ Unloaded | 1 h, 8 h, 24 h | *S. enterica* | IAI | Real time quantitative PCR and Immunoassay | Conical implant-abutment connections do not prevent microleakage on amolecular level. |
| Park S et al., [11] In vitro | GS II RBM Fixture; Osstem Implant/n=40 | Internal hexagon | 20 Ncm/16000 times | 7 days | 0.5% Solution of basic fuchsin | Access holes of implant prosthesis retained with screw. | Spectrophotometer . | The microleakage was reduced when the access holes were sealed with gutta-percha or vinyl polysiloxane. |
| Rismanchian M et al., [1] In vitro | ITI implants/ n=36 | Cast on, castable, solid, and synocta abutments | 35 Ncm/Static condition | 5 h-14 days | *E. coli* | IAI | Scanning electron microscope | Premachined titanium abutments reduce the amount of microgap when compared with cast on and castable abutments. |
| Baggi L et al., [12] In vitro | Dentsply Friadent, Astra Tech AG, GTB, Mega' Gen, Straumann, Nobel Biocare / n=120 | Tube-in-tube interface; Flat-to-flat interface | 15-35N/ Static condition | 7 days | *S. sanguinis, F. nucleatum, A. odontolyticus, C. albicans, C. glabrata* | IAI | Culture and scanning electron microscopy | Tube-in-tube interface implants were more resistant to colonization. Torque value suggested by manufacturer showed less colonization than lower torques given manually. |
| Giorgini G et al., [13] In vitro | --------- | Locking tapered connection | -------- | 24 h | Bacteria | IAI and the implant-healing cap interface | X-ray micro-tomography | Hermetic barrier against microbial leakage was provided by implant-healing cap tapered connection |
| Cavusoglu Y et al., [14] In vitro | Straumann implant/n=10 | Zi abutment/ Ti implant interface; Ti abutment/ Ti implant interface. | 35 Ncm/ 500 000 cycles | ------ | Acrylic resin | IAI | SEM with X-ray microanalysis | In loaded condition Zi abutment/Ti implant interface shows microleakage approaching the screw joint. The integrity of the implant abutment interface was compromised by difference in material. |
| Koutouzis T et al., [15] In vitro | Custom Dental Implants/ n=40 | Internal Morse-taper connection. | 25 Ncm/500000 cycles | 5 days | *E. coli* | IAI | Colony forming units (CFU) were counted. | Morse-taper connection showed minimal penetration of bacteria down to the IAI. Penetration of bacteria increased on dynamic loading |
| Nayak AG et al., [16] In vitro | ADIN Dental Implant Systems/ n=45 | Unsealed group, sealed with O-rings, sealed with gap Seal gel. | 20 N/ Static condition | 5 days | *Enterococcus* | IAI | Digital colony counter | Least growth was observed in the gap seal group followed by the O-ring group. When more torque was used and less leakage has been observed |
| Sahin C et al., [17] In vitro | Medical Instinct; EZ, Megagen Implant/ n=3 | Intenal hex Ti, Internal hex Zi, Morse tapered Ti | 25 Nm/ Static loading | 20 min | Deionized water | IAI | Modified fluid filtration method | Higher microleakage was observed at the implant-internal hex Zi abutment. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Smith NA and Turkyilmaz I [18] In vitro | Nobel Replace / n=46 | External hexagon | 20 Ncm and 35 Ncm/ Static condition | Daily evaluation was done till leakage was observed. | *P. intermedia, P. gingivalis, F. nucleatum* | IAI | Electronic colony counter | Smaller microgap was observed in implant with titanium abutment than implant with zirconia abutment. Increase of torque from 20 Ncm to 35 Ncm decreases the microgap of zirconia abutment. |
| Verdugo CL et al., [19] In vitro | MG Mozo-Grau Osseous/n=42 | External connection; Conical internal connection (Morse taper) | 20 N and 30 N | 24 hour | 0.2% methylene blue | IAI | Optical microscopy | Less microleakage was shown by Morse taper connection implants then external connection implants; Increase torque decreases the microleakage . |
| Abdelhamed MI et al., [20] In vitro | Astratech-implants/n=32 | Implant with Titanium (Ti) and Zirconia (Zi) abutments | 15 Ncm and 25 Ncm/Static condition | 5 minutes, 25 h, and 195 h. | *E. coli* | IAI | Limulus amebocyte lysate (LAL) test and Toluidine blue dye penetration test | At 15 Ncm torque microleakage of Zi was higher with time when compared with Ti; Zi when torqued at 15 Ncm showed higher microleakage with time in comparison to Zi torqued at 25 Ncm. |
| Al-Jadaa A et al., [21] In vitro | Astra Tech (A), Biomet 3i (B); Nobel Biocare (C))/ n=30 | Taper lock and internal hexagonal (A); Flat-to-flat interface and internal hexagonal mating surface (B); Flat-to-flat and a trilobe mating (C) | Group A and Group B 20 Ncm and Group C 35 Ncm; Static and dynamic loading 1'200'000 cycles | 2 days | Bacteria | IAI | Gas Enhanced Permeation Test (GEPT) | Best leakage resistance was shown by group B under static and dynamic conditions. |
| Canullo L et al., [22] Human Study | Biome T3i, Premium-Kohno, Astra Tech / n=80 | External hexagon double internal hexagon; Internal hexagon with external collar; Conical connection. | Functionally loaded | 5 yrs | *A. actinomyc-etemcomitans, P. gingivalis, T. forsythensis, T. denticola, P. intermedia, P. micros, F. nucleatum, Campylobacter rectus, Eikenell-acorrodens, C. albicans* | Conn-ection's inside and the abutment surface (CIAS) | Quantitative real-time PCR | Microleakage was not prevented at IAI by any design of connections. At the peri-implant sulcus and inside the connection less bacterial leakage was shown by internal hexagon with external collar and conical connection. |
| D'Ercole S et al., [23] In vitro | -------- | Two different implant connections. | ------- | 14 days | *E. faecalis; A. actinomy-cetemcomitans* | IAI | Scanning electron microscopy | No leakages through the I-A interface were demonstrated for either type of connection evaluated. |
| Dias Resende CC et al., [24] In vitro | Neodent/ n=30 | Morse taper | 32 Ncm and 15 Ncm/ Static condition | 7 and 30 days | *S. sanguinis, F. nucleatum* | Micro-leakage from the inner part and microl-eakage in to the inner part of implant | Turbidimetry test | When the prosthetic index changed, sealing of the Morse taper junction is efficient and there was lower microleakage under static conditions. |
| Do Nascimento C et al., [25] In vitro | Duo system and Duoconsystem/ n=48 | External hex (EH) /Morse cone (MC) | 20 Ncm / 500000 cycles | ------- | 38 bacterial species including (*P. gingivalis, T. forsythia, T. Denticola*); 5 *Candida* species | IAI | Checkerboard DNA-DNA hybridization | Higher microbial count was found in EH implants than MC implants. Colonization of microorganisms was not found at the internal surfaces of MC implants. |
| Ranieri R et al., [26] In vitro | Morse taper system/ n=4 | Internal hex | 25 Ncm, 20 Ncm, 32 Ncm/ Static loading | 48 h | *S. sanguinis* | IAI | Scanning electron microscopy | Morse taper implant system does not provide resistance to bacterial leakage at IAI. |
| Tripodi D et al., [27] In vitro | Cone Morse taper/ n=20 | Internal connection | 500,000 cycles | 14 days | *E. faecalis* | IAI | Histological method | Both unloaded and dynamic loading do not show any differences in the microbial leakage. |
| Alves DCC et al., [28] In vitro | Morse taper implants and tapered screwed implants / n=48 | Internal conical screw less connection; Tapered screw-retained implant prosthesis | 20 Ncm/ 500,000 cycles | 14 days | *E. coli* | IAI | Scanning electron microscopy | There was no effective sealing of tapered implant/ abutment. Effective sealing was not obtained due to imprecise machining of implant parts. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Gherlone EF et al., [29] In vitro | Bicon, Astra Tech, Biosafin, Sweden e Martina/ n=80 | Morse locking taper; Conical connection, Internal hexagonon; Internal connection, double taper | Torque used as recommended by manufacturer/ Static condition. | 1h, 3 h, 6h, 16 h, 24 h, 48 h, 72h and 96 h | *E. coli* | IAI | Bacterial growth evaluation | Internal connection, double taper at 96 hours showed less bacterial microleakage when compared to other internal connections. |
| Guerra E et al., [30] In vitro | Easy grip, Connect AR, AR Torq/ n=150 | Internal hexagon, External hexagon, Morse taper | 20 Ncm/Static loading | 14 days | *E. coli, S. sanguinis* | IAI | Scanning electron microscopy | No difference in bacterial leakage was found among different implant abutment connections. |
| Khorshidi H et al., [31] In vitro | CSM Implants and TBR Implants/ n=20 | 11 degree internal Morse Connection; Butt joint connection | 30 N-cm/ Static condition | 14 days | *S. mutans* | IAI | Colony count and turbidity | Morse taper implant showed more resistance to microbial leakage in comparison to butt joint implants. |
| Koutouzis T et al., [32] In vitro | Morse taper system Astra Tech / n=40 | Conventional margin, Sloped margin design | 25 Ncm torque/ 500,000 cycles | 5 days | *E. coli* | IAI | Colony forming units (CFU) were counted | Under dynamic loading sloped marginal design implants showed same bacterial invasion at IAI as conventional marginal design implants. |
| Mencio F et al., [33] In vitro | n=12 | Screwed connection; Cemented connection | -------- | 14 days | Bacterial species | IAI | PCR-Real time analysis | In both the connections bacterial species penetrated at IAI; The lowest bacterial penetration was shown at cemented connection implants. |
| Peruzetto WM et al., [34] In vitro | Morse taper system/ n= 22 | Tapered implant connections with indexed and non indexed abutments | 20 N | 14 days | *E. coli* | IAI | Microbiological analysis | No adequate sealing against bacterial leakage was shown by both tapered components. A superior seal was shown by indexed type components. |
| Pita MS et al., [35] In vitro | EH - Biodent HEX RP; TI Bioneck TRI RP/ n=48 | External hexagon; Tri-channel internal connection | 32 Ncm/ Unloaded | 7 days | 35 bacterial species and 3 *Candida* species | IAI | Checkerboard DNA–DNA hybridization | In both the external (EH) and internal (TI) connections large number of microbial species penetrated at IAI; Implants attached with conical head abutment screws showed less microorganisms in comparison to conventional flat-head screws. |
| Wachtel A et al., [2] In vitro | Perio Type Rapid Implants/ n=7 | An internal octagonal butt joint | 30 Ncm/ 1000000 cycles | 24 h | *E. faecium* | IAI | Kanamycin-Aesculnazide Agar (KAAA), as optical indicator for *E. faecium* | Three implants showed bacterial leakage under static condition. At low number of load cycles bacterial leakage occurred in other implants. |
| Zipprich H [36] In vitro | Fourteen implant systems/ n=70 | Conical and flat implant abutment connection. | As recommended by manufacturers/ 1200000 cycles | 15 min | *S. sanguinis, S. mutans, A. viscosus, F. nucleatum, V. parvula* | IAI | Florescence microscopy | Under static loading bacterial contamination was not observed. Under dynamic loading conical implant abutment connection offers better seal. |

**[Table/Fig-2]:** Studies on microleakage at the different implant connections [1,2,9-36].
n= number, IAI= Implant Abutment Interface, h = hours, *P. intermedia = Prevotella intermedia, P. gingivalis = Porphyromonas gingivalis, F. nucleatum = Fusobacterium nucleatum, T. forsythia = Tannerela forsythia, T. denticola = Treponema denticola, E. coli = Escherichia coli, S. sanguinis = Straptococcus sanguinis, A. odontolyticus = Actinomyces odontolyticus, C. albicans = Candida albicans, C. Glabrata = Candida Glabrata, E. faecium = Enterococcus faecium, S. enterica = Salmonella enteric, V. parvula = Veillonparvula, A. actinomycetemcomitans = Aggregatibacter actinomycetemcomitans, P. micros = Peptostreptococcus micros, E. corrodens = Eikenella corrodens, C. gingivalis = Capnocytopha gagingivalis*

## DISCUSSION

Today a lot of implant systems are available in market with various abutment implant connections. External connection systems were most common connections and composed of external hexagons. This design has many disadvantages such as there is little contact length between the restoration and the hexagonal part of the implant head. There is some degree of rotation between the platform and the internal hexagon of the restoration. There is great tension created in the screw connection. In the internal hexagonal system, the hexagon and the screw pass into the implant body so the prosthetic component is more stable. The force generated in this type of connection is dissipated to the walls adjacent to the hexagon of the implant [19].

At present one of the major causes for implant failure is peri-implantitis, which is a destructive inflammatory process that occurs around osseointegrated implants due to colonization of bacteria [37]. The commonly seen complication of peri-implantitisis destruction of bone induced due to bacteria. The type of implant abutment connection plays a very important role in leakage of bacteria. Tissues adjacent to the IAI revealed a marked infiltration of inflammatory substances irrespective of the amount of plaque accumulation [38].

Do Nascimento C et al., evaluated the bacterial leakage in an External Hexagon (EH) implant connection in non loaded condition using DNA checkerboard and culture methods. They found that bacterial leakage from the IAI was same in both the methods [9]. Verdugo CL et al., 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 [19]. 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 [19,39]. Morse taper implant-abutment connection has an 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 [40].

Canullo L et al., conducted a five year follow up study on human for different implant connections under functional loading. Result showed that microbial contamination was seen in all the connections. IH and conical connections implant showed less leakage of bacteria at the peri-implant sulcus and inside the connection than external hexagon implants [22]. Do Nascimento C et al., in their in vitro study used 43 microbial species which were very common in the human oral cavity. They evaluated prosthesis supported by External Hexagon (EH) or Morse Cone (MC) implants under dynamic loading conditions. Results revealed that higher microbial count was found in EH implants than MC implants. Many microbial species including peri-implant diseases causing organisms were detected in internal part of EH implants. Internal surfaces of MC implants showed no colonization of microorganisms, as microgaps present in conical connections were much smaller at IAI [25].

Pita MS et al., in their study tested both conventional flat-head and conical-head abutment screws, in EH and Trichannel Internal-platform (TI) implants, under unloaded condition with 38 microbial species. In both the EH and TI connections large number of microbial species penetrated at IAI. Implants attached with conical head abutment screws showed fewer microorganisms in comparison to conventional flat-head screws [35]. Similar results obtained by Zipprich H et al., in their evaluation of fourteen different implant systems with conical and flat implant system. Under static loading conditions bacterial contamination was not observed in any system but under dynamic loading conical implant abutment connection offers better seal [36]. A possible reason for this may be microgaps and hollow spaces were reduced in these assemblies after attachment of abutment, so it limits the penetration of the microbes [35].

Smith NA et al., studied the EH implants and found that smaller microgap was observed in implant with titanium (Ti) abutment than implant with Zirconia (Zi) abutment. When torque was increased from 20 Ncm to 35 Ncm the microgap of Zi abutment was reduced. The study noted smallest microgap of 2 µm in the Ti abutment and largest microgap as 26.7 µm in the Zi abutment [18]. RismanchianM et al., found in their study that premachined Ti abutments reduce the amount of microgap when compared with Cast On and Castable abutments. The reasons for the microgap on the fitting surfaces of Cast On and Castable abutments may be due to lack of finishing and polishing procedures [1]. CavusogluY et al., evaluated the Zi abutment/Ti abutment with Ti implant interface under loading conditions and found that Zi abutment/Ti implant interface shows microleakage approaching the screw joint [14]. The integrity of the implant abutment interface was compromised by difference in material. Zi-abutments showed wear area of 8.3 times larger than Ti abutments [41]. In another study by Abdelhamed MI et al., at 15 Ncm torque microleakage of Zi was higher with time when compared with Ti. Zirconia abutment when torqued at 15 Ncm showed higher microleakage with time in comparison to Zi torqued at 25 Ncm [20]. Sahin C et al., in their study on Morse taper implant found that higher microleakage was observed at the implant-internal hex Zi abutment. The minimum microleakage was found to be in between Morse tapered Ti abutment surfaces and implant [17]. Studies had shown 5 times higher microleakage at implant-internal hex Zi (I-IhZ), than the Ti connection. A reason for this was milled surface of the zirconium abutments was rougher than the titanium due to which mating of the surfaces was not obtained properly and there was more adhesion of microorganism [42,43].

Baggi L et al., in their study found that tube-in-tube interface implants were more resistant to colonization than flat to flat interface [12] but contradictory result obtained by Al-Jadaa A et al., where they found implants with a flat-to-flat interface and internal hexagonal mating surfaces showed the best performance with regard to leakage under both static and dynamic conditions. This study also proved that if implants under static conditions were tight, it will provide better sealing ability under dynamic conditions [21].

Koutouzis T et al., evaluated microleakage of internal Morse-taper connection and found that there was minimal penetration of bacteria down to the IAI [15]. Dynamic loading increases the penetration of bacteria as there was micro movement at the IAI which causes a pumping effect and leads to detrimental effects on the marginal bone stability [44]. Contradictory result was obtained by Harder S et al., where conical implant-abutment connections do not prevent microleakage on a molecular level in even unloaded conditions [10].

The result of study by Ranieri R et al., showed that Morse taper implant system does not provide resistance to bacterial leakage at IAI [26]. Tripodi D et al., evaluate the bacterial leakage in Cone Morse implant-abutment connections and found that in both unloaded and loaded assemblies, bacterial contamination was found in two out of 10 implant-abutment interface [27]. Guerra E et al., in their study found no difference in bacterial leakage among IH, EH and Morse taper connections [30]. Khorshidi H et al., in their study found that Morse taper implant showed more resistance to microbial leakage in comparison to butt joint implants. A 90-degree angle was formed in butt joint connection where as in case of Morse conical connection one funnel surface goes inside the other so it is more efficient considering the biological aspects [31]. Koutouzis T et al., found in their research that in dynamic loading conditions, sloped marginal design implants had same microbial penetration at the IAI microgap when compared to conventional marginal design implants. An internal Morse-taper connection of 11° taper angle between the implant and the abutment was used in both groups. Sloped margin design implants were introduced in cases where there was large deficiency at the buccal and lingual portion of the alveolar ridge [32]. Mencio F et al., evaluated the screwed connection and cemented connection. In both the connections bacterial species penetrated at IAI. The lowest bacterial penetration was shown at cemented connection implants [33].

The abutment is present into the oral cavity and if the bacterial infiltration can be prevented through IAI, the initiation of microbial infection can be prevented in the peri-implant tissues [29]. Depending on the different implant systems a microgap in the range of about 1 to 49 µm can be seen at the IAI. When the implant is subjected to masticatory forces the gap at IAI is further widened [24]. For achieving the best coupling effect the torque values suggested by the manufacturers should be followed as the deficient interface closure due to manual torque causes penetration of microorganism into the implants [12]. Precise machining and finishing procedures are must to improve implant interface [1].

## LIMITATION

Limitation of this systematic review is that it includes only articles published in English and articles search was done from only Medline, Pubmed and EBSCO host database. This review contains only one study on human, so the result of the review should be taken with caution till further human research is done in future to clear the situation.

## CONCLUSION

In this systematic review maximum studies showed that there was some amount of microleakage at abutment implant interface. 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 also showed less microleakage in dynamic loading conditions. Torque recommended by manufacturer should be followed strictly to get a better seal at abutment implant interface. Zirconia abutments are more to microleakage than Titanium abutments and there use should be discouraged. Zirconia abutments should be only restricted to cases where there was very high demand of aesthetics.

## REFERENCES


[1] Rismanchian M, Hatami M, Badrian H, Khalighinejad N, Goroohi H. Evaluation of microgap size and microbial leakage in the connection area of 4 abutments with Straumann (ITI) implant. J Oral Implantol.2012;38:677-85.
[2] Wachtel A, Zimmermann T, Spintig T, Beuer F, Müller WD, Schwitalla AD. A novel approach to prove bacterial leakage of implant-abutment connections in vitro. J Oral Implantol. 2016;42:452-57.
[3] Passos SP, Gressler May L, Faria R, Ozcan M, Bottino MA. Implant-abutment gap versus microbial colonization: clinical significance based on a literature review. J Biomed Mater Res B Appl Biomater.2013;101:1321-28.
[4] Jansen VK, Conrads G, Richter EJ. Microbial leakage and marginal fit of the implant-abutment interface. Int J Oral Maxillofac Implants.1997;12:527-40.
[5] Callen DP, O'Mahony A, Cobb CM. Loss of crestal bone around dental implants: a retrospective study. Implant. Dent.1998;7:258-66.
[6] Hecker DM, Eckert SE, Choi YG. Cyclic loading of implant-supported prostheses: Comparison of gaps at the prosthetic-abutment interface when cycled abutments are replaced with as-manufactured abutments. J Prosthet Dent. 2006;1:26-32.
[7] Dheda SS, Kim YK, Melnyk C, Liu W, Mohamed FA. Corrosion and in vitro biocompatibility properties of cryomilled spark plasma sintered commercially pure titanium. J Mater Sci Mater Med. 2013;24:1239-49.
[8] Glauser R, Siler I, Wohlwend A, Studer S, Schibli M, Scharer P. Experimental zirconia abutments for implant-supported single-tooth restorations in esthetically demanding regions: 4-year results of aprospective clinical study. Int J Prosthodont.2004;17:285-90.
[9] Do Nascimento C, Miani PK, Pedrazzi V, Muller K, de Albuquerque RF Jr. Bacterial leakage along the implant-abutment interface: culture and DNA Checkerboard hybridization analyses. Clin Oral Implants Res. 2012;23:1168-72.
[10] Harder S, Quabius ES, Ossenkop L, Kern M. Assessment of lipopolysaccharide microleakage at conical implant-abutment connections. Clin Oral Invest. 2012;16:1377-84.
[11] Park S, Lee Y, Kim Y, Yu S, Bae J, Cho H. Microleakage of different sealing materials in access holes of internal connection implant systems. J Prosthet Dent. 2012;108:173-80.
[12] Baggi L, Di Girolamo M, Mirisola C, Calcaterra R. Microbiological evaluation of bacterial and mycotic seal in implant systems with different implant-abutment interfaces and closing torque values. Implant Dent. 2013;22:344
[13] Giorgini G, Santangelo R, Bedini R, Pecci R, Manicone PF, Raffaelli L, et al. Dimensional and microbiological in vitro analysis of a dental implant locking taper connection. J Biol Regul Homeost Agents. 2013;27:1077-82.
[14] Cavusoglu Y, Akça K, Gürbüz R, Cehreli MC. A pilot study of joint stability at the zirconium or titanium abutment/titanium implant interface. Int J Oral Maxillofac Implants. 2014;29:338-43.
[15] Koutouzis T, Mesia R, Wong NCF, Wallet S. The effect of dynamic loading on bacterial colonization of the dental implant fixture–abutment interface: An in vitro study. J Oral Implantol. 2014;40:432-37.
[16] Nayak AG, Fernandes A, Kulkarni R, Ajantha GS, Lekha K, Nadiger R. Efficacy of antibacterial sealing gel and O-ring to prevent microleakage at the implant abutment interface: An in vitro study. J Oral Implantol. 2014;40:11-14.
[17] Sahin C, Ayyildiz S. Correlation between microleakage and screw loosening at implant-abutment connection. J Adv Prosthodont. 2014;6:35-38.
[18] Smith NA, Turkyilmaz I. Evaluation of the sealing capability of implants to titanium and zirconia abutments against *Porphyromonas gingivalis, Prevotellainter media,* and *Fusobacterium nucleatum*. J Prosthet Dent. 2014;112:561-67.
[19] Verdugo CL, Núñez G J, Avila AA, San Martín CL. Microleakage of the prosthetic abutment/implant interface with internal and external connection: in vitro study. Clin Oral Implants Res. 2014;25:1078-83.
[20] Abdelhamed MI, Galley JD, Bailey MT, Johnston WM, Holloway J, McGlumphy E, et al. A comparison of zirconia and titaniuma butments for microleakage. Clin Implant Dent Relat Res. 2015;17(Suppl 2):e643-e51.
[21] Al-Jadaa A, Attin T, Peltomäki T, Heumann C, Schmidlin PR. Impact of dynamic loading on the implant-abutment interface using a gas-enhanced permeation test in vitro. Open Dent J. 2015;9:112-19.
[22] Canullo L, Penarrocha-Oltra D, Soldini C, Mazzocco F, Penarrocha M, Covani U.Microbiological assessment of the implant-abutment interface in different connections: cross-sectional study after 5 years of functional loading. Clin Oral Implants Res. 2015;26:426-34.
[23] D'Ercole S, Tripodi D, Marzo G, Bernardi S, Continenza MA, Piattelli A, et al. Microleakage of bacteria in different implant-abutment assemblies: An in vitro study. J Appl Biomater Funct Mater. 2015;13:e174-80.
[24] Dias Resende CC, Carolina Castro G, Pereira LM, Prudente MS, Zancopé K, Davi LR, et al. Influence of the prosthetic index into Morse Taper implants on bacterial microleakage. Implant Dent. 2015;24:547-51.
[25] Do Nascimento C, Ikeda LN, Pita MS, Pedroso e Silva RC, Pedrazzi V, de Albuquerque RF, et al. Marginal fit and microbial leakage along the implant-abutment interface of fixed partial prostheses: An in vitro analysis using Checkerboard DNA-DNA hybridization. J Prosthet Dent. 2015;114:831-38.
[26] Ranieri R, Ferreira A, Souza E, Arcoverde J, Dametto F, Gade-Neto C, et al. The bacterial sealing capacity of Morse Taper implant–abutment systems in vitro. J Periodontol. 2015;86:696-702.
[27] Tripodi D, D'Ercole S, Iaculli F, Piattelli A, Perrotti V, Iezzi G. Degree of bacterial microleakage at the implant-abutment junction in Cone Morse tapered implants under loaded and unloaded conditions. J Appl Biomater Funct Mater. 2015;13:e367-71.
[28] Alves DCC, de Carvalho PSP, Elias CN, Vedovatto E, Martinez EF. In vitro analysis of the microbiological sealing of tapered implants after mechanical cycling. Clin Oral Invest. 2016;20:2437-45.
[29] Gherlone EF, Capparé P, Pasciuta R, Grusovin MG, Mancini N, Burioni R. Evaluation of resistance against bacterial microleakage of a new conical implant-abutment connection versus conventional connections: an in vitro study. New Microbiol. 2016;39:49-56.
[30] Guerra E, Pereira C, Faria R, Jorge AO, Bottino MA, de Melo RM. The impact of conical and nonconical abutments on bacterial infiltration at the implant-abutment interface. Int J Periodontics Restorative Dent. 2016;36:825.
[31] Khorshidi H, Raoofi S, Moattari A, Bagheri, A, Kalantari MH. In vitro evaluation of bacterial leakage at implant-abutment connection: An 11-degree Morse Taper compared to a butt joint connection. Int J Biomater. 2016;2016:1-5.
[32] Koutouzis T, Gadalla H, Lundgren T. Bacterial colonization of the implant-abutment interface (IAI) of dental implants with a sloped marginal design: An in-vitro study. Clin Implant Dent Relat Res.2016;18:161-67.
[33] Mencio F, Papi P, Di Carlo S, Pompa G. Salivary bacterial leakage into implant-abutment connections: preliminary results of an in vitro study. Eur Rev Med Pharmacol Sci. 2016;20:2476-83.
[34] Peruzetto WM, Martinez EF, Peruzzo DC, Joly JC, Napimoga MH. Microbiological seal of two types of tapered implant connections. Braz Dent J. 2016;27:273-77.
[35] Pita MS, do Nascimento C, Dos Santos CG, Pires IM, Pedrazzi V. Experimental conical-head abutment screws on the microbial leakage through the implant-abutment interface: an in vitro analysis using target-specific DNA probes. Clin Oral Implants Res. 2016 May 19.
[36] Zipprich H, Miatke S, Hmaidouch R, Lauer HC. A new experimental design for bacterial microleakage investigation at the implant-abutment interface: An in vitro study. Int J Oral Maxillofac Implants. 2016;31:37-44.
[37] Mombelli A, Decaillet F. The characteristics of biofilms in peri-implant disease. J Clin Periodontol. 2011;38:203-13.
[38] Mawhinney J, Connolly E, Claffey N, Moran G, Polyzois I. An in vivo comparison of internal bacterial colonization in two dental implant systems: identification of a pathogenic reservoir. Acta Odontol Scand. 2015;73:188-94.
[39] Dibart S, Warbington M, Su MF, Skobe Z. In vitro evaluation of the implant-abutment bacterial seal: the locking taper system. Int J Oral Maxillofac Implants. 2005;20:732-37.
[40] Macedo JP, Pereira J, Vahey BR, Henriques B, Benfatti CAM, Magini RS, et al. Morse taper dental implants and platform switching: The new paradigm in oral implantology. Eur J Dent. 2016;10:148-54.
[41] Klotz MW, Taylor TD, Goldberg AJ. Wear at the titanium- zirconium implant-abutment interface. A pilot study. Int J Oral Maxillofac Implants. 2011;26:970-75.
[42] Verran J, Maryan CJ. Retention of Candida albicans on acrylic resin and silicone of different surface topography. J Prosthet Dent. 1997;77:535-39.
[43] Taylor R, Maryan C, Verran J. Retention of oral microorganisms on cobalt-chromium alloy and dental acrylic resin with different surface finishes. J Prosthet Dent. 1998;80:592-97.
[44] Hermann JS, Schoolfield JD, Schenk RK, Buser D, Cochran DL. Influence of the size of the microgap on crestal bone changes around titanium implants. A histometric evaluation of unloaded non-submerged implants in the canine mandible. J Periodontol. 2001;72:1372-83.



**PARTICULARS OF CONTRIBUTORS:**

1. Reader, Department of Maxillofacial Prosthodontics and Implantology, Peoples College of Dental Sciences and Research Centre, Bhopal, Madhya Pradesh, India.
2. Professor, Department of Maxillofacial Prosthodontics and Implantology, Rajarajeswari Dental College and Hospital, Bangalore, Karnataka, India.
3. Postgraduate Student, Department of Orthodontics and Dentofacial Orthopaedics, Rishiraj College of Dental Sciences and Research Centre, Bhopal, Madhya Pradesh, India.

**NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:**
Dr. Sunil Kumar Mishra,
Reader, Department of Maxillofacial Prosthodontics and Implantology,
Peoples College of Dental Sciences and Research Centre, Bhopal, Madhya Pradesh, India.
E-mail : drsunilmishra19@gmail.com



**FINANCIAL OR OTHER COMPETING INTERESTS:** None.

Date of Submission: Mar 30, 2017
Date of Peer Review: Apr 19, 2017
Date of Acceptance: May 20, 2017
Date of Publishing: Jun 01, 2017