

To Evaluate And Compare Microleakage Of Different Implant Abutment Connection Designs – An In Vitro Study

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Abstract— Statement of problem: The formation of a marginal gap between the implant and abutment might lead to increased loss of marginal bone due to penetration of bacteria into the implant-abutment interface. As of yet, there are no endosseous dental implant systems that can provide a complete seal at the implant-abutment interface and so this is still an important clinical issue. The testing of different implant abutment connections which may be a factor affecting microleakage is necessary for the successful outcome of dental implant prosthesis.

Aim: The aim of this study was to evaluate and compare microbial leakage at the implant-abutment interface in different implant-abutment connection designs.

Material and Method: Implants and abutments with conical hex (n1=10) and morse taper (n2=10) implant abutment connection designs were procured for the study. Specimens of each group were contaminated with tryptic soy broth cultivated with E. coli bacteria and incubated for 5 days at 37°C. After incubation a swab was taken from the internal surface of the implant and transferred onto culture plates of blood agar nutrient media and incubated for 48 hours. The growth and viability of the E. coli determined the microleakage. Statistical analysis was done by unpaired t-test. The level of significance was set at p<0.05.

Results: Microleakage was seen in all the specimens. Conical hex IAI exhibited less microleakage. There was significant difference between conical hex and morse taper connection designs.

Conclusion: Within the limitation of the current study it can be concluded that conical hex connection design implants showed reduced microleakage than morse taper connection design implants.

Keywords: conical hex, morse taper, implant, IAI, microleakage, bacteria, E. coli

I. Introduction

Dental implants, which have great success and outstanding survival rates, are currently the most popular procedure for replacing a missing tooth. An endosteal implant and an abutment, which are joined to the implant by a screw, make up the basic implant system. A two-stage implant process that achieves good osseointegration reduces the risk of an implant being exposed to stress too soon.¹ However, this success is not reliant on a single aspect; rather, it depends on a number of circumstances, including precise treatment planning, adequate oral hygiene, adequate bone density, and an improvement in the physical, mechanical, and chemical qualities of the implant and its components.² The implant is a biocompatible foreign body that is inserted into the mouth. All of the modern implant systems that are currently in use are made of biocompatible materials based on titanium, zirconium oxide, or tantalum. In order to improve loading of the implants and expand the area of its surface in contact with the alveolar bone, numerous alternative implant forms and surfaces have been developed.² Dental implants are very successful, with a projected 10% failure rate. Bone loss, a lack of osseointegration, microbiological leakage, the design of the prosthesis, premature loading, poor positioning of a prosthesis, etc. are possible causes of implant failure. The main cause of implant failure is microbial leakage at the Implant abutment interface.¹

The implant-abutment connection is the weakest part of an endosseous implant assembly because it resists masticatory stresses that are constant and bacterial infiltration. Because of masticatory loads that may result in tiny movements of the prosthesis parts, this microgap may grow larger over time. By using physically tight connection designs in the submicrometer range, every implant maker tries to lower implant-abutment connection mobility.³ The gradation of microbial penetration in an implant system rests on several factors, including the correctness of fit between the implant and abutment, the amount of component micromovement, and the torque used. The inner surface of the implant and the adjacent peri-implant tissue are connected by a pump action when the micro gap widens.² When a micro gap exists at the IAI, it encourages bacterial leakage because it enables microorganisms to enter the interior of the implant, which ultimately causes the buildup of biofilm and peri-implantitis.⁴ Further this marginal gap at the implant-abutment assembly, contributes to the damage of marginal bone by allowing bacteria to spread into the implant-abutment interface. The fact that there are currently no endosseous dental implant systems that can generate a complete seal at the IAI must be acknowledged, and this remains a substantial clinical problem. It has been hypothesized that this displacement will result in more stress and strain on the endosseous implant, accelerating the loss of marginal bone.⁴ There are two different types of implant-abutment interaction designs: internal and external. The system that was previously employed, called the external connection, is made up of external hexagons. A drawback of the design was that there was very little space between the restoration and the hexagonal portion of the implant head. Currently internal connections are popularly used due to advantages of reduced microleakage and provision for platform switching. Microleakage over the implant-abutment interface is an intriguing study subject, especially given the growing popularity of implant insertion and development of new IAI designs. Limited literature is available for

comparison between microleakage at IAI in various internal connection designs. Culture method is one of the standard and reliable method to assess microleakage. Therefore, the present study was taken up to evaluate and compare microleakage at the IAI in implant systems with conical hex and morse taper connection designs, using microbiological growth and culture method.

II. Materials and methods

This study was conducted in the Department of Prosthodontics and Crown & Bridge, Darshan Dental College and Hospital, Loyara, Udaipur and Department of Microbiology, Ravindra Nath Tagore Medical College, Udaipur to evaluate and compare microleakage at implant-abutment interface in different implant abutment connection designs. 20 dental implants were procured for the study and divided into 2 groups (10 each). Group I with Conical hex implant-abutment connection (Adin Dental Implant Systems Ltd.) and Group II with Morse taper implant-abutment connection (Veritas Bioventions Pvt. Ltd.). The implants and abutments were taken out from the packaging and checked for any damage to them. The abutments were then fitted on the implants and torqued according to the manufacturer's instructions. The implants were held in the packaged container to avoid movement of implants while torquing. Escherichia coli was used as a contaminant medium for the incubation of the implant-abutment assemblies. The bacteria were first scraped with a loop from the ATCC strain culture plate and immersed into test tubes containing tryptic soy broth and mixed thoroughly. Before collecting the bacteria in the loop for the next specimen it was heated red hot over a spirit lamp and then cooled for few seconds as to prevent air-borne contamination and transmission. After mixing the bacteria in the test tubes, the contaminant solution so formed was poured from the test tubes into three glass containers, one for each group. The attachment assemblies from each group were then invested into respective glass container with contaminant solution in it. These assemblies were suspended into the glass container through a thermoplastic sheet with circular holes cut out of diameter of 2 mm. They were suspended in such a way that the E. coli contaminated culture broth would cover 1 mm above the IAI. This was done so that solution did not contaminate the screw channel access thereby eliminating the risk of contamination through the screw opening. After placing implant abutment assemblies in contaminant solution, they were incubated at 370 for 5 days. After the incubation period, the assemblies were removed, rinsed with spirit, dried and autoclaved so as to prevent outside contamination. The implant and abutment assemblies were opened and the contents from the inner surface of the implant-abutment interface from all the three groups were collected with sterile microbrushes. The nutrient media was infused with blood to make it blood agar nutrient medium. A pool was created into the culture plate containing blood agar nutrient media and with the help of loop streaking was done starting through the pool for the specimens of all three groups. The loop was heated over the spirit lamp in between streaking so as to avoid cross-contamination. These culture plates were later incubated for 48 hours at 370 C. Based on the growth of the bacteria, colony forming units were counted and microleakage was evaluated for all the specimens of both the groups. The collected data was tabulated and statistically analysed (IBM SPSS software). The mean and standard deviation of the microleakage of specimens in each group was calculated. Statistical analysis for the calculated data was done by unpaired t-test. The level of significance was set at the probability level of $p \leq 0.05$. Conclusions were drawn based on statistical analysis.

III. Results

This in-vitro study was conducted to evaluate and compare the microleakage resulting at implant-abutment interface in different implant abutment connection designs. The study was divided into 2 groups, Group I (conical hex implants) and Group II (morse taper implants).

Table 1 shows microleakage at conical hex implant abutment interface (Group I). The mean of the number of colonies formed of Escherichia coli on culture plates in Group I (conical hex IAI) was 6.50 ± 6.399 . Table 2 shows microleakage at morse taper implant abutment interface (Group II). The mean of the number of colonies formed of Escherichia coli on culture plates in Group II (morse taper IAI) was 100000.00 ± 0.00 . Table 3 shows descriptive statistics of mean and standard deviation (Mean \pm S.D) of Group I and Group II. The Mean \pm S.D for Group I (conical hex IAI) was 6.50 ± 6.399 and for Group II (morse taper IAI) was 100000.00 ± 0.00 . Table 4 shows t-test for equality of means for comparing microleakage at IAI in different implant abutment connection designs. On statistical analysis the value of p was 0.000, indicating highly significant difference between the groups ($p \leq 0.05$).

Table 1: Microleakage at Conical hex Implant abutment interface (Group I)

Specimen Number	Number of colonies
1	5
2	3
3	8
4	4
5	2
6	3
7	24
8	4
9	6
10	6

Mean ± S.D	6.50 ± 6.399
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Table 2: Microleakage at morse taper Implant abutment interface (Group II)

Specimen number	Number of colonies
1	10 ⁵
2	10 ⁵
3	10 ⁵
4	10 ⁵
5	10 ⁵
6	10 ⁵
7	10 ⁵
8	10 ⁵
9	10 ⁵
10	10 ⁵
Mean ± S.D	100000 ± 0.000

Table 3: Descriptive statistics for microbial leakage at implant-abutment interface in different groups

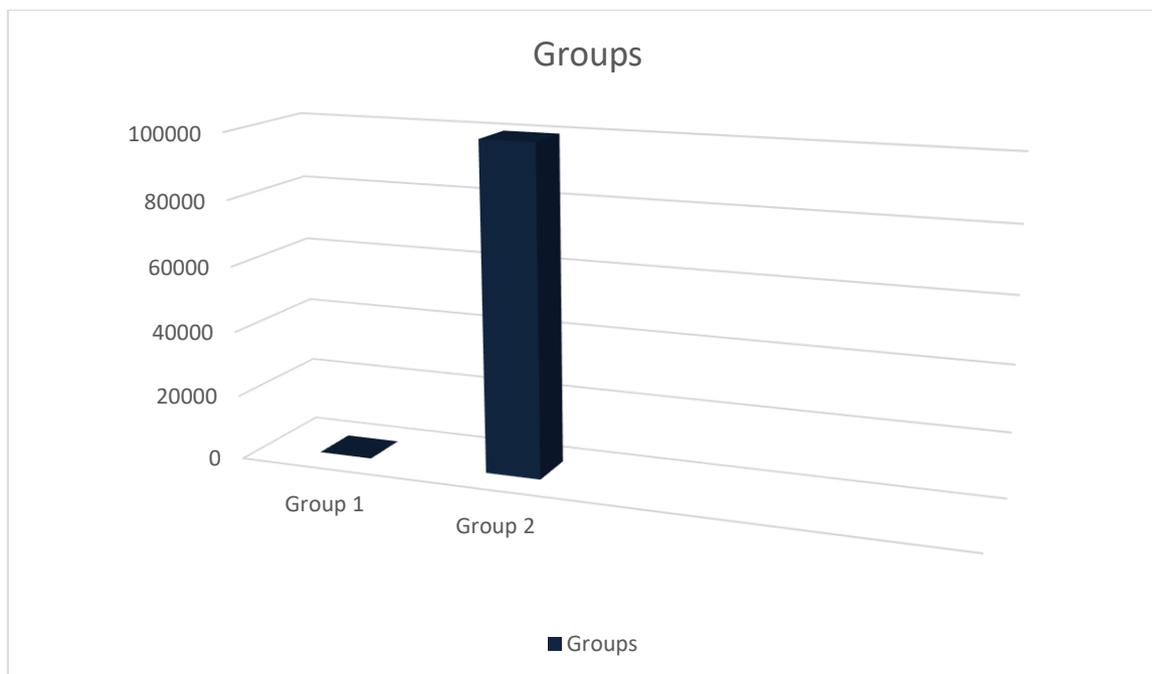
Group	N	Microleakage		
		Mean	Std. Deviation	Std. Error Mean
I	10	6.50	6.399	2.023
II	10	100000.00	.000	.000

Table 4: Unpaired t-test for microbial leakage at implant-abutment interface in different groups

		t-test for Equality of means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Group	Equal variances assumed	49416.761	18	.000	99993.500	2.023	99997.751	99989.249

*Level of significance $p \leq 0.05$.

Graph 1: Mean number of colonies of E. coli formed at implant-abutment interface



Group 1: Conical hex implants

Group 2: Morse taper implants

IV. Discussion

Implant-supported dental prostheses are broadly used in clinical dentistry to replace absent teeth. Most clinical studies have reported high success rates for implant restorations, with reliable long-term results for single crown, partial, and complete restorations. Primary implant stability failure after the surgical process is related to early dental implant loss and constitutes the major determinant of osseointegration success. Infections in the peri-implant tissues due to inflammatory reactions caused by microbial colonization have been reported and associated with failed implants, a condition that occurs in 56% of treated individuals. At present one of the major causes for implant failure is periimplantitis, which is a destructive inflammatory process that occurs around osseointegrated implants due to the colonization of bacteria. The most frequent side effect of peri-implantitis is bone loss brought on by bacterial infection. In terms of bacterial leakage, the type of implant abutment connection is crucial. Irrespective of the degree of plaque buildup, tissues near the IAI showed a clear infiltration of inflammatory chemicals.

The implant and abutment in two-stage implant systems are separated by cavities and gaps. Inflammatory reactions in the soft tissues surrounding the implant may result from these hollow spaces acting as a trap for germs. The peri-implantitis of the osseointegrated implant can be brought on by bacterial infection, which can prevent osseointegration during the healing phase of the surgical operation. In the course of treating periimplantitis, the pathogenic bacterial microflora may have an impact on the success of guided bone regeneration. In implant systems with screw-retained abutments, it has been found both in vitro and in vivo that leakage at the implant-abutment contact can allow bacteria to enter the internal cavity of the implant.³⁴ Halitosis and peri-implant illnesses including peri-implant mucositis and peri-implantitis can be brought on by microgap at the implant-abutment interface, which can operate as a favorable region for the accumulation and development of bacteria. Such inflammatory conditions may impair bone healing and may eventually result in bone loss. Also, positioning of implant-abutment interface next to the level of the alveolar bone crest in submerged implants is one reason for peri-implant bone loss through the first year after loading of implants. A wide variety of microorganisms seem able to penetrate the implant components. *E. coli* has been extensively used for in vitro assessment of microleakage since it can be effortlessly cultured and it proliferates in a short period of time.

Jansen et al (1997) analyzed several implant-abutment interfaces in relation to microbial penetration in vitro. He found that even morse taper implant systems cannot safely prevent microbial leakage and bacterial colonization of the inner part of the implant. Gross et al measured the amount of microleakage that occurred at the implant-abutment interface in 5 implant systems, and they used different torques to attach the abutments to the implants. All systems showed microleakage, however, the degree of the microleakage varied with the applied torque. The amount of microleakage was dramatically reduced when the torque was increased from 10 to 20 Ncm. The manufacturers specified torque was applied, and this reduced the microleakage throughout all systems. They came to the conclusion that by tightening the abutments to the tension advised by the makers, microbial leakage and associated negative effects, such as halitosis, soft tissue irritation, and peri-implant bone loss, can be considerably reduced. A possible explanation is that micro gaps in conical connections are much smaller with less leakage at the implant-abutment interface. Although this connection cannot totally prevent leakage of microorganisms and fluids, it may retard or reduce microbial penetration and colonization. Microbial cell death and/or genetic material degradation may have occurred because of the reduced amount of nutrients in the small gaps resulting from the MC connection. In the present study, it was observed that microleakage occurred at the IAI of both the conical hex and morse taper IAI evaluated. Further, there was a statistically significant difference between the microleakage of both the implant abutment connection designs. Conical hex exhibited less microleakage when compared to the

morse taper implant abutment connection. This result was similar to various researchers who studied microleakage at IAI of various connection designs and have concluded that microleakage occurred in different amounts in various implant abutment connection studies. In a study conducted by Canullo L et al, in which he conducted a five-year follow-up study on humans for different implant connections under functional loading. This result showed that microbial contamination was seen in all the connections. Internal hexagon and conical connection implants showed less leakage of bacteria at the peri-implant sulcus and inside the connection than external hexagon implants.

In another study conducted by Do Nascimento C et al, 43 microbial species that were widely distributed in the human oral cavity were chosen. Under dynamic loading circumstances, they examined prostheses supported by External hexagon and Morse taper implants. Results showed that external hexagon has a higher microbial count than morse taper implants. Microgaps in morse taper connection is substantially less at IAI, indicating that microbes had not colonized the inside surface of morse taper implants.

When Quirynen et al examined the internal surface of Branemark dental implants for the presence of viable bacteria, they discovered that all specimens had extremely high levels of germs, primarily cocci and immobile rods. Wahl et al extracted a large variety of bacteria from the interior surface of IMZ implants in a clinical investigation, and many of these organisms resembled the anaerobic flora found in patients with periodontal disease. Gross et al (1999) showed that screw connected interference-fit joints also allowed the passage of fluids through the implant-abutment interface. Later, Brogginini et al (2003) demonstrated an increase in inflammatory cells at the level or slightly coronal to the implant-abutment connecting interface on soft tissues around two-piece implants. Koka et al (1993) confirmed bacterial colonization after 14 days of insertion of the abutment in the implant. The 14-day monitoring period of the present study corroborates the findings of other studies, as being sufficient time to permit the passage of bacteria through the prosthetic interface. Jansen et al stated that even implant systems with the optimal fit between components cannot perfectly prevent bacterial leakage. There are limited studies available on comparing microleakage between IAI of internal conical and morse taper attachments.

In a study conducted by Dominico Todi et al, they compared microleakage between internal hex and morse taper connections and found no significant difference between the two connection designs. This result was contrary to the results of the present study where conical hex were found to be statistically significantly different from morse taper attachments.

This study had some limitations like the sample size of the study was less, microbial leakage in some samples was so high that it could have complicated the accurate counting of colony-forming units and although the bacterial microleakage was evaluated in this study, it is still feasible that bacterial products that are much smaller than the bacteria themselves could enter the inside of implants. It is advised that future research should assess molecular microleakage.

Further studies can be conducted in an in-vivo environment to stimulate clinical situations, different types of implant-abutment connections could be tested, an alternate approach might be used to assess the relative microleakage, sample size can be increased.

V. Conclusion

Within the limitations of this study, the following can be concluded:

- Microleakage is present between the implant abutment interface irrespective of the connection design.
- Conical hex IAI showed less microleakage than morse taper IAI.
- Implant abutment connection has microgaps, which allowed for microscopic bacterial leakage.
- Microleakage is associated with various factors like design of the IAI, small micromovements and optimal fit of components, proper prosthetic design and optimal occlusion.
- Implantologist must ensure designing a prosthesis in order to minimize factors leading to microleakage at IAI.

VI. References

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