ORIGINAL RESEARCH

Assessment of Microgap and Microbial Leakage of Two Different Implant-abutment Interfaces: An *In Vitro* Study

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Abstract

Aim: The purpose of the current study was to evaluate Titanium and Bioneck TRI implant-abutment interfaces for microgaps and microbiological leakage.

Materials and methods: In this *in vitro* experiment, 40 dental implants were split into two groups, each of which had 20 samples. Group I: Titanium dental implant, group II: Bioneck TRI. *E. coli* strain was cultivated in MacConkey media for 24 hours at 37°C. To achieve a bacterial concentration of 1 x 10^8 colony-forming units per mL at 0.5 scale of MacFarland, the brain-heart infusion (BHI) broth was injected. The CFU count was done to evaluate the microbial leakage. The parts were first submerged, carefully cleaned in an ultrasonic bath, and then installed using a digital torque meter with a 20 N/cm preload. These were attached to a stub of approximately 13 mm using carbon tape, and the microgap evaluation was performed using a scanning electron microscope at a magnification of x1000. Unpaired *t*-test was used for the calculated data's statistical analysis. The *p*-value less than 0.05 was considered as statistically significant.

Results: The maximum microbial leakage was in Bioneck TRI implants (10000 ± 0.01) followed by Titanium dental implants (8.60 ± 3.16). The mean difference was 9991.40 and there was a statistically significant difference found between the two different groups. The maximum microgap was found in the Bioneck TRI implants (9.72 ± 0.96), followed by Titanium dental implant (6.82 ± 1.10) and there was a statistically significant difference was found between the groups ($p < 0.001$).

Conclusion: The present study concluded that the microorganisms can infiltrate the microgap between the implant and abutment interface. When compared with Titanium dental implants, Bioneck TRI implants showed significantly higher levels of microbial leakage.

Clinical significance: A microgap between the implant and abutment connection might operate as a bacterial source, may produce inflammation, even osseointegration in danger, and subsequently alter clinical and histological parameters. Therefore, having an understanding of the compatible components aids in overcoming treatment planning challenges.

Keywords: Abutments, Dental implants, Microbial leakage, Microgap.

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Introduction

Dental implantology has entered the mainstream of dentistry in recent years. The Titanium fixture, abutment, and prosthesis make up the three primary components of implant restorations. The abutment is mechanically linked to the implant's surface and must remain in place for the duration of the implant's life in order to avoid issues. For the prosthesis to function properly, it is crucial to keep the implant and abutment relationship stable. The design, fit accuracy, materials utilized, screw geometry, degree of friction, preload, and abutment shape are just a few of the many variables that affect how stable an implant-abutment interface is.[1]

The microgap is the small distance between the implant fixture and abutment. This gap is typically measured in microns and is present at the alveolar crest level. Microgaps between the implant and abutment have been linked to bone loss and peri-implant inflammation. It is significant to remember that those who have undergone treatment for periodontal disease are more likely to develop peri-implantitis. Before each surgical phase, pathogens in the oral cavity must be reduced by effective plaque control.[2] A microgap may serve as a microbiological source, endangering the mucosal seal. Periodontal disease will spread as a result of changes in clinical and microbiological characteristics, which puts osseointegration at risk.[3]

Gram-positive cocci to gram-negative rods appear to be able to penetrate implant components, according to the findings of

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Quirynen et al.[4] The authors discovered microorganisms linked with peri-implantitis inside Branemark System implants, including *Streptococcus constellatus*, *Bacterioides* sp., *Peptostreptococcus micros*, and *Fusobacterium* sp. Inflammatory infiltrates may be present near to the I–A interface if microorganisms are present there.

All currently used modern implant systems are constructed from biocompatible materials based on Titanium, zirconium oxide, or tantalum. Numerous implant forms and surfaces have been created in order to enhance loading of the implants and increase the area of its surface in contact with the alveolar bone.[5]

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Conflict of interest: None

Table 1: Microbial leakage evaluation at implant–abutment interface in two different groups

		Microleakage	
Groups	*n*	*Mean ± SD*	*Std. Error Mean*
Group I: Titanium dental implant	20	8.60 ± 3.16	1.98
Group II: Bioneck TRI	20	10000 ± 0.01	0.01

Table 2: Comparison of microbial leakage evaluation at implant–abutment interface in two different groups using unpaired *t*-test

					95% Confidence interval of the difference	
Groups	*t value*	*df*	*Mean difference*	*p-value**	*Lower*	*Upper*
Two groups – equal variances	26586.824	16	9991.40	0.001	9892.06	9896.14

*HS, highly significant

The degree of bacterial colonization between the implants and abutments has been found to be influenced by the tightening torque, fit precision, and micro motions among the associated equipment during mastication.[6] Both external connections and internal connections can be used to categorize all connection patterns between an implant and its corresponding abutment. These vary greatly, notably in terms of surface and fit precision. Hence, the purpose of the current study was to evaluate Titanium and Bioneck TRI implant-abutment interfaces for microgaps and microbiological leakage.

Materials and Methods

The present study was conducted in the department of Periodontics and Oral Implantology, Kalinga Institute of Dental Sciences, Bhubaneswar, India, during the year of 2022. In this *in vitro* experiment, 40 dental implants were used, which were divided into two groups with 20 samples each.

Group I: Titanium dental implant – It has an interior hexagon with a 3.75 mm diameter and a 10 mm length and was a standard platform. (ADIN Dental Implants, Israel)

Group II: Bioneck TRI – Internally, it contains a 13-mm-long, 3.5-mm-diameter tri-channel connector (Derig Implantes, Barueri, Sao Paulo).

Microbiological Assessment

For 24 hours at 37°C, the *E. coli* strain was cultivated in MacConkey media. The brain-heart infusion (BHI) broth was inoculated to produce bacteria with a concentration of 0.5 scale of MacFarland (1 x 108 colony-forming units per mL) with an absorbance range of 0, 8–1.1 and 625 Nm.[7] About 5 mL of tainted BHI was placed in test tubes with the assembly. For 36 hours, they were cultivated at 37°C. The abutments were removed from the implants. To minimize the possibility of contamination, the disconnection and the sampling from the inner portion of the implant with sterile paper cones were performed.

After 36 hours, the implants were removed from the test tubes and cleaned with 80% alcohol for 3 minutes and dried with sterile gauze to avoid external contamination. This method ensured internal cell survival without compromising outward sterility. The paper cone to be used was immersed in 2 mL of sterile BHI at 37°C for 24 hours. The turbidity of the medium was examined and classified using a MacFarland scale based on the level of turbidity, and then measured using spectrophotometry. Finally, 15 µL was taken and cultured in MacConkey agar for 24 hours at 37°C for further 24 hours to perform the CFU count for all the samples.

Microgap Assessment

The implant and abutment parts were first submerged, carefully cleaned in an ultrasonic bath, and then installed using a digital torque meter with a 20 N/cm preload. Four assessment locations were specified by the placement of the implant analog abutment set on acrylic support. These blocks were fixed on a 13 mm stub using carbon tape before being examined using a scanning electron microscope (JSM 6510LV 15 kV, JEOL, Japan). The images were made at × 1,000 magnification. At four chosen sites (rotating in 90° increments), measurements were made right on the microscope. For the statistical analysis of the data, the mean microgap values for all samples were taken into consideration as the typical gap measurement at the implant-abutment interface. Two investigators were involved in the present study.

Statistical Analysis

The data were analyzed using SPSS version 20 statistical software. Each group's samples' mean and standard deviation for microleakage and microgap were computed. Unpaired *t*-test was used for the calculated data's statistical analysis. *p*-value less than 0.05 was considered statistically significant.

Results

Table 1 depicts the microbial leakage evaluation at implant-abutment interface in two different groups. The microbial leakage was 8.60 ± 3.16 in Titanium dental implants and 10000 ± 0.01 in Bioneck TRI implants.

Table 2 depicts the comparison of microbial leakage evaluation at implant-abutment interface in two different groups using an unpaired *t*-test. The maximum microbial leakage was in Bioneck TRI implants (10000 ± 0.01), followed by Titanium dental implants (8.60 ± 3.16). The mean difference was 9991.40 and there was a statistically significant difference found between the two different groups.

Table 3: Assessment of microgap at implant–abutment interface in two different groups

Groups	*n*	*Mean ± SD (mμ)*	*p-value*	*Significance*
Group I: Titanium dental implant	20	6.82 ± 1.10	0.001	HS
Group II: Bioneck TRI	20	9.72 ± 0.96		

Microgap at implant-abutment interface in two different groups was assessed in Table 3. The maximum microgap was found in the Bioneck TRI implants (9.72 ± 0.96), followed by Titanium dental implant (6.82 ± 1.10) and there was a statistically significant difference between the groups (*p*-0.001).

The inference of the present study indicates that the microgap between implant and abutment interface can be the site of penetration of bacteria. Significantly. higher microbial leakage was observed in Bioneck TRI implants compared with Titanium dental implants.

Discussion

Osseointegrated dental implants have grown in significance in recent years in the field of oral rehabilitation for patients who are partially or totally edentulous, and successful implant therapy necessitates a delicate balance between biological and mechanical factors that affect the efficacy of oral implants.[8] The implant is inserted at the initial surgical stage of an implant system, and the abutment is then screwed onto the implant to support the prosthetic restorations. The implant-abutment interface is formed by the mating surfaces of the implant and its abutment and is regarded as a key component of implant design. The quantity of microbiological leakage between the two components may depend on how the fixture–abutment interface is made. Abutment misfit and microgaps have been linked to a number of problems, including screw loosening, microleakage, component abrasion and wear, the possibility of bone loss, and the micropump effect.[9,10]

The microgap in the current investigation ranged from 6.82 to 9.72 mμ. According to several research works, the implant-abutment connection's microgap size ranged from 1 to 50 mμ. According to the type of abutment, the size of the microgap was reported to range from 7 to 74 mμ in the study by Rismanchian et al.[11] Depending on the kind of abutment, Fernandez et al.[12] showed that the microgap size ranged from 0.73 to 11.30 mμ. According to Tsuge et al.,[13] the average microgap ranges from 3.2 to 5.6 mμ. Additionally, in a research work done by Scarano et al.,[14] the microgap measured 40 mμ in cemented prosthesis and 60 mμ in screw prostheses.

E. coli was selected for this study as, *E coli* is a frequently used test microorganism for *in vitro* investigations, particularly for sterilization, disinfection, and contamination purposes. It has a quick 20-minute generation time and is simple to handle in the lab. Additionally, it can be discovered in the oral cavity of healthy people.[15]

In the current study, Bioneck TRI implants had the highest levels of microbiological leakage and microgaps, followed by Titanium dental implants. Similar *in vitro* experiments carried out by Scarano A et al.,[16] Do Nascimento C et al.,[17] and Grobecker-Karl T et al.[18] have shown that bacteria infiltration may happen both from an exterior source to the inside area of an implant and in reverse. The unavoidable existence of microgaps between the fixture and the abutment components of the completed system is likely what facilitates this bacterial translocation. The amount of bacterial buildup increases with microgap size and results in peri-implant disease. These microgaps could become even wider under clinical loads if the screw joint becomes loose due to bending pressures during function.

Peri-implantitis, a damaging inflammatory disease that develops around osseointegrated implants as a result of bacterial colonization, is currently one of the main reasons for implant failure. 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.[19]

Steinebrunner L et al.[20] state that the degree of bacterial penetration in a particular Titanium implant system is likely a multifactorial condition dependent on the accuracy of fit between the implant and abutment, the amount of micromovement between the components, and the torque forces used to connect them. However, evaluations of connective or antirotational elements at various interfaces are still required. Some investigations have demonstrated a high precision of fit at the outer interface of implant-abutment assemblies.

The limitation of the present study includes the size of the implants and the difficulty in maintaining sterile conditions throughout the experiment creates some handling challenges for *in vitro* investigations with microorganisms. It is also challenging to quantify the quantity of leakage that is discovered at the interface and to carry out studies using a live bacterial population. However, more research is required to assess the bacterial microleakage as well as the toxicity of its toxins. For a clearer assessment of the significance of the microgap on bacterial microleakage, these tests should be carried out in various implant systems and loading situations.

Conclusion

Within the limitation, the present study concluded that microorganisms can infiltrate the microgap between the implant and abutment interface. When compared with Titanium dental implants, Bioneck TRI implants showed significantly higher levels of microbial leakage.

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