ORIGINAL ARTICLE

In vitro Evaluation of Microleakage at Dental Implant Abutment Interface of Titanium and Zirconia Abutments under Different Torquing Forces

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ABSTRACT

Aim: The aim of the study was to evaluate the microleakage at titanium implant abutment and titanium implant zirconia abutment interface under 20 n and 30 n torque.

Background: The amount of bacterial infiltration between the implants and the abutments depends on the materials, the fit accuracy between the pieces and tightening torque applied to the connected components which may ultimately lead to peri-implantitis and bone loss around this area.

Materials and Methods: A total of 60 titanium implants were taken and divided into two groups, Group A consisting of 30 titanium implant and abutments and Group B consisting of 30 titanium implants with zirconia abutments. These groups were further classified into four subgroups of 15 titanium implant abutment screwed with a torque of 20 Ncm; 15 titanium implant abutment screwed with a torque of 30 Ncm; 15 titanium implant with zirconia abutment screwed with a torque of 20 Ncm; and 15 titanium implant with zirconia abutment screwed with a torque of 30 Ncm. The sterilized implants were assembled and then inserted in sterile brain heart infusion broth tubes inoculated with *Enterococcus*. The tubes were incubated for 24 h, 48 h, 120 h, and 7 days. The entire apparatus was removed from the tubes, dried aseptically and placed in 1% sodium hypochlorite solution for 20 min again dried aseptically; dismantled and put in sterile brain heart infusion broth tubes, incubated for 48 h and assessed for microbial growth.

Results: Data will be subjected to statistical analysis by Kruskal–Wallis ANOVA test and Mann–Whitney U-test.

Conclusion: Within the limitations of the present study, it may be concluded that the connection design and type of abutment material affect the microbiological sealing capability and marginal fit of abutments. The zirconia abutments with an internal conical connection seem to be more resistant to bacterial leakage.

Keywords: Microleakage, Dental implant, Torquing forces.

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How to cite this article: Nayak AG, Meshramkar R, Anehosur GV, Shaikh SA. *In vitro* Evaluation of Microleakage at Dental Implant Abutment Interface of Titanium and Zirconia Abutments under Different Torquing Forces. Int J Med Oral Res 2019;4(1):10-13.

Source of support: Nil

Conflicts of interest: None

INTRODUCTION

Dental implant rehabilitation has been widely used in clinical practice to replace missing teeth with high success and survival rates. An ideal relationship between an implant and the peri-implant tissues is necessary to achieve functional and esthetic restorations that can be accomplished with a careful balance of several parameters.[1,2] Establishment of stable hard and soft tissues around the implant is related to some biological, technical, and prosthetic considerations such as the implant surface, surgical technique, and prosthetic design. Since the introduction of dental implants, manufacturers have attempted to perfect the design of the implant-abutment connection by developing different connection types.[3] They can be generally classified into external and internal connections. Dental implants and abutments are generally made of commercially pure titanium due to the high physical properties and biocompatibility of the material.[4-6] However, titanium abutments might display an unnatural grayish discoloration through thin, soft tissue, compromising optimal mucogingival esthetics. Alternative abutment materials have been sought to overcome such disadvantages. Zirconia abutments are frequently preferred for their esthetic properties and biocompatibility. Abutments with different connection designs or material types are placed on the implants with a torque value recommended by the manufacturer to ensure accurate fit and minimize microleakage.[7] Success in implant therapy demands a balance between biological and mechanical factors. Microleakage through the interface has been documented in implant systems with titanium abutments as well as zirconia abutments. The amount of bacterial infiltration between the implants and the abutments also depends on factors such as the fit accuracy between the pieces and tightening torque applied to the connected components.[8,9] The implant abutment interface correlated with bacterial infiltration and inflammatory cells can lead to bone loss around this area.[10-14] The aim of the present *in vitro* study is to evaluate the leakage at the implant-abutment interface under the influence of different torque forces.

AIMS AND OBJECTIVES

The aims are as follows:
1. Evaluation of microleakage at titanium implant-abutment interface.
2. Evaluation of microleakage at titanium implant and zirconia abutment interface.
3. Evaluation of microleakage at titanium implant abutment interface under an applied torque of 20 n, 30 n.
4. Evaluation of microleakage at titanium implant and zirconia abutment interface under an applied torque of 20 n, 30 n.

METHODOLOGY

A total of 60 titanium implants will be taken and divided into two groups largely: Group A consisting of 30 titanium implant and abutments and Group B consisting of 30 titanium implants with zirconia abutments. These groups will be further classified into four sub groups of 15 titanium implant abutment screwed with a torque of 20 Ncm; 15 titanium implant abutment screwed with a torque of 30 Ncm; 15 titanium implant with zirconia abutment screwed with a torque of 20 Ncm; and 15 titanium implant with zirconia abutment screwed with a torque of 30 Ncm. The implants will be assembled and then sterilized. The four groups or the test specimens will be then inserted in sterile brain heart infusion broth tubes and inoculated with *Enterococcus*. The tubes will be incubated for 24 h, 48 h, 120 h, and 7 days. The entire apparatus will be removed from the tubes, dried aseptically and placed in 1% sodium hypochlorite solution for 20 min again dried aseptically; dismantled and put in sterile brain heart infusion broth tubes, incubated for 48 h and will be assessed for microbial growth.

RESULTS

The multivariate Kruskal–Wallis test revealed significant differences among the groups OF Tukey HSD and Scheffe (ZIRABT20, ZIRABT30, TITABT20, TITABT30, ZIRABT20, ZIRABT30, TITABT20, and TITABT30) for the tested parameters (bacterial leakage and marginal fit) ($P < 0.05$). The results of bacterial leakage are presented in Table 1. Statistically significant difference was found among the groups based on the results of leaked colonies ($P < 0.05$) [Table 1]. No significant difference was found among the groups for the leaked colonies ($P > .05$). The lowest bacterial leakage was found in zirconia group characterized by an internal conical connection and Zr abutment.

DISCUSSION

Inflammation of the peri-implant tissues is considered as one of the primary causes leading to implant failures. The long-term success of dental implants is affected by several factors related to the implant-abutment connection, including microbiological, mechanical, and technical aspects.[2] To maintain clinical relevance, peri-implantitis associated anaerobic bacteria, which is known as "red complex," was used in the present study. However, the level of leakage could be affected by the methodology and the volume of bacterial concentration used to inoculate the inner parts of implants.[10,12] In the present study, a volume of 0.7 µL bacterial suspension was used to inoculate the implants, which is determined after several laboratory trials to be sufficient to avoid false positive or false negative results. However, the polymicrobial combination used in the present study has not been used in any other study. To increase clinical relevance, a polymicrobial culture responsible for peri-implant diseases that are consisted of *Porphyromonas gingivalis*, *Tannerella forsythia*, *Treponema denticola*, and *Fusobacterium nucleatum* were prepared. Statistically significant differences were found among the groups based on the results of leaked colony-forming units. In accordance with the present study, the conical connections had been reported to be more resistant to bacterial leakage than the other connection designs.[10,13] Nevertheless, increased leakage for Zr abutments compared to Ti abutments was reported, possibly due to the lower recommended torque values used to tighten the Zr abutments.[15] However, greater bacterial adhesion to titanium surfaces when compared to zirconia had been reported by Nascimento *et al.*[16] Different findings among the studies could be explained with the differences in the methodology such as bacteria used, sampling techniques, closing screw torque values, and characteristics of implant systems. Statistically significant differences were found among the groups concerning the results of marginal fit in the present study. There are also studies reporting higher or lower microgap values for the same abutments in previous studies. Baixe *et al.*[17] reported the size of the microgap in the range of 0.25–18.93 µm for Zr Nobel Replace abutments with the tri-channel connection. In another study by Hamilton *et al.*,[18] the mean microgap size was reported to be 47.7 µm for Ti Nobel Replace

Table 1: Bacterial leakage among the groups

(I) GRP			Mean difference (I-J)	Standard error	Sig.	95% confidence interval	
						Lower bound	Upper bound
Tukey HSD	ZIRABT20	ZIRABT30	461.881*	110.312	0.001	168.91	754.85
		TITABT20	45.576	117.836	0.980	−267.37	358.52
		TITABT30	449.400*	108.393	0.001	161.53	737.27
	ZIRABT30	ZIRABT20	−461.881*	110.312	0.001	−754.85	−168.91
		TITABT20	−416.305*	119.603	0.006	−733.95	−98.66
		TITABT30	−12.481	110.312	0.999	−305.45	280.49
	TITABT20	ZIRABT20	−45.576	117.836	0.980	−358.52	267.37
		ZIRABT30	416.305*	119.603	0.006	98.66	733.95
		TITABT30	403.824*	117.836	0.006	90.88	716.77
	TITABT30	ZIRABT20	−449.400*	108.393	0.001	−737.27	−161.53
		ZIRABT30	12.481	110.312	0.999	−280.49	305.45
		TITABT20	−403.824*	117.836	0.006	−716.77	−90.88
Scheffe	ZIRABT20	ZIRABT30	461.881*	110.312	0.002	142.95	780.81
		TITABT20	45.576	117.836	0.985	−295.10	386.26
		TITABT30	449.400*	108.393	0.002	136.02	762.78
	ZIRABT30	ZIRABT20	−461.881*	110.312	0.002	−780.81	−142.95
		TITABT20	−416.305*	119.603	0.012	−762.09	−70.52
		TITABT30	−12.481	110.312	1.000	−331.41	306.45
	TITABT20	ZIRABT20	−45.576	117.836	0.985	−386.26	295.10
		ZIRABT30	416.305*	119.603	0.012	70.52	762.09
		TITABT30	403.824*	117.836	0.014	63.14	744.50
	TITABT30	ZIRABT20	−449.400*	108.393	0.002	−762.78	−136.02
		ZIRABT30	12.481	110.312	1.000	−306.45	331.41
		TITABT20	−403.824*	117.836	0.014	−744.50	−63.14

*The mean difference is significant at the 0.05 level

abutments with tri-channel connection and 22.3 μm for Ti Nobel Bränemark System abutments with the external hexagonal connection. The differences among the studies could be explained with different technical conditions such as reference points, sample size, and deformation due to the cross-sectioning.[16,17,19,20] Further, *in vitro* and *in vivo* studies are necessary to determine the effects of connection design and abutment material on the microleakage and marginal fit by simulating the loading conditions of the intraoral environment and different closing screw torque values.

CONCLUSION

Within the limitations of the present study, it may be concluded that the connection design and type of abutment material affect the microbiological sealing capability and marginal fit of abutments. The zirconia abutments with an internal conical connection seem to be more resistant to bacterial leakage. It was found that zirconia abutment screwed with a torque of 30 Ncm causes lesser microleakage as compared to others.

ACKNOWLEDGEMENT

We would like to thank Rajiv Gandhi University of Health Sciences for funding this study with reference number: RGU:Adv.Res.Proposal-D-38:2015-16 date: 6.1.2016

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