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Original Article

The Effect of Saliva Ph on the Electrical Galvanic Current Between Titanium Implant and Cobalt Chromium Bar Attachment

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ABSTRACT

Objectives: *The present study was carried out to evaluate the effect of Ph changes of the saliva on the electrical galvanic currents between the anodizing titanium implant with cobalt chromium bar attachment. Material and methods: Eighteen dental implants (9 model each model 2 dental implants with bar). Every two titanium implants were inserted within acrylic block, a cobalt chromium bar was used to connect the two implants and attached to it with titanium screws. The blocks of acrylic resin with dental implant and cobalt chromium bar classified into three groups according to the artificial saliva Ph (neutral, acidic and alkaline). Following immersion in artificial saliva the flow of galvanic current between titanium dental implant and cobalt chromium bar was measured after 7 and 30 days. The data was statistically analysis used F-test (ANOVA) to compare between the groups and post hoc test (LSD) for pairwise comparison. Results: the result of this study showed that there was statistically significant different between the groups, with higher galvanic current in acidic Ph group. Conclusion: Within the limitation of this in vitro study, there where galvanic current between titanium dental implant when coupled with cobalt chrome bar and it significantly increased with the time especially when immersed in acidic media.*

Keywords: Saliva, Galvanic Current, Titanium Implant, Cobalt.

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INTRODUCTION

Practically pure titanium and its alloys have been widely used for dental implants due to their mechanical properties, biocompatibility and good corrosion resistance in biological fluids [1]. However, according to Manan et al. [2], metals of high corrosion resistance may corrode when in contact with body fluids, depending on the environment conditions. Different factors have been reported that may affect the corrosion behavior of the material such as metals inserted in oral region might be exposed to pH changes [3]. Also, the temperature and the presence of proteins [4], and bacteria [5], also the salts concentration might have great effect [6]. In addition to difference in oxygen concentration, dental plaque,

microorganisms and mechanical stress that could increase the corrosion rate [7, 8]. Study by olmedo et al. (2003) has observed that ionic release induced by corrosion could be responsible for peri-implantitis and treatment failure [9]. Moreover, the corrosion process may limit the metal's resistance to fatigue, that may cause fracture of the implant [10]. The corrosion products can be distributed throughout the entire body, and may even cause allergic reactions (Type IV) or a hypersensitivity reaction [11]. There are several types of corrosion that may occur in dental implants, such as, pitting, crevice and galvanic corrosion. Galvanic corrosion occurs when dissimilar alloys are placed in direct contact within the oral cavity or within the tissues. When saliva penetrates into prosthetic components in contact with implants, the metal dissolution generates currents, due to a potential difference created by the formation of a galvanic cell [12, 13]. In vivo studies showed that when different materials come into contact with corrosive fluids a potential difference is established between metals may create galvanic cells [12,13]. The galvanic cell may be formed between the two dissimilar alloys in the prosthesis structure or between the implant and the castable framework when they are screw-retained directly in the implant body [14,15]. Based on the different chemical compositions of the alloys, a difference between the electrochemical electrode potentials is expected, this potential difference is a basic requirement for the incidence of galvanic corrosion when Nicle Chrome is coupled with titanium. These potential difference produces electric current flow that accelerates anodic dissolution of the less noble metal currents, that may have influenced by the area ratio, the total surface area of the galvanic couple and the particular conditions of each individual [16]. A current generated by galvanic corrosion may result in discomfort to the patient and can be the cause of onset of bone resorption [17]. A decrease in the corrosion resistance of alloys may influence their biocompatibility, generating an inflammatory response in the surrounding tissue and allowing environment infiltration into rehabilitation, leading to the loss of rehabilitation integrity and failure [18, 19, 20]. The consequences of the galvanic current were observed to vary depending on the location in the mouth, due to the degree of oral mucosa keratinization among others [21]. The present study was carried out to evaluate the effect of pH changes of the saliva on the electrical galvanic currents between the anodizing titanium implant with cobalt chromium bar attachment.

METHODS

The alloys used in this study were the anodizing titanium dental implant and cobalt chromium bar. The elemental composition of the alloys provided by the manufacturers is shown in Table 1.

Table 1: Composition of studied dental alloys.

Casting alloys	Composition & proportion of ingredient by weight (%)
Ti6ai4 (ti101)	Ti 89.A l6. V4.Trace element 1.
Cobalt-chrome (BEGO)	Co 63.8. Cr 24.8. W 5.3. Mo 5.1. Si 1.0.

Eighteen dental implants (9 model each model 2 dental implants with bar). Every two titanium implants were inserted within acrylic block with space in between (20-22mm). The collar section of the implant flushed with the model cast. A cobalt chromium bar was constructed in conventional manner (castable bar system) connecting the two implants and attached to it with titanium screws (fig.1). The blocks of acrylic resin with dental implant and cobalt chromium bar classified into three groups according to the artificial saliva Ph. Group A:

(artificial saliva with normal Ph (6-8)). Group B (artificial saliva with acidic Ph (5)). Group C (artificial saliva with alkaline Ph (8)).

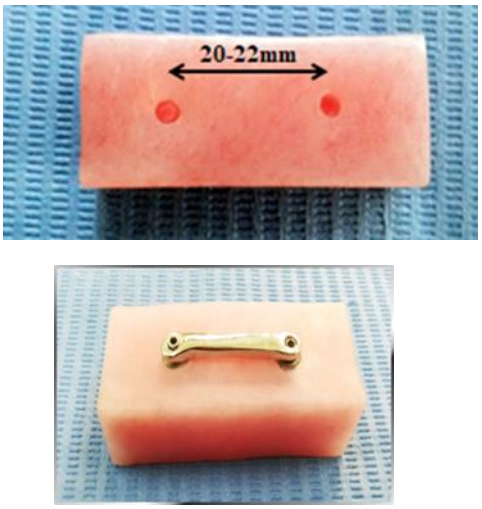

Figure 1: Acrylic block

Each specimen then was placed in a separate glass container with artificial saliva and incubated at 37°C (to mimic temperature of oral cavity) using an incubator for 7and 30 days (fig 2).

Figure 2 specimens in incubator

Following immersion in artificial saliva the flow of galvanic current between titanium dental implant and cobalt chromium bar was measured after 7 and 30 days (during immersion in solution) using digital multimeter (fig 3). Depending on the electrode potential of the metal in the electrolytic medium (artificial saliva), one act as the anode and the other act as cathode. The titanium was used as cathode and the Co-Cr as the anode.

Figure 3 Digital multimeter

The data was collected and analyzed using SPSS software package version 20.0. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level. In this study used F-test (ANOVA) to compare between the groups, and post hoc test (LSD) for pairwise comparison.

RESULTS

The galvanic current between titanium dental implant and cobalt chromium bar was measured at different Ph level (normal, acidic and alkaline) at two immmersion time (7 and 30 days). According to the result of Anova test followed by Post Hoc test for pairwise comparsion, there was significant different ($P \leq 0.05$) between normal and acidic, and between alkaline and acid, and between normal and alkaline groups. Table. 2, 3 and fig. 4 show the comparsion between different groups according to current measurement (MA) after 7 and 30 days consequency. Moreover, there was statistacally significant difference at $P \leq 0.05$ between 7 and 30 days' immersion time at the different Ph level, table 4 show the comparison between the two periods according to current (MA) in each group.

Table 2. Comparison between the different groups according to current (MA) after 7 days (: Statistically significant at p ≤ 0.05)*

7days	Neutral (n=3)	Acidic Ba (n=3)	Alkaline (n=3)	p
Current (MA)				
Min. – Max.	5.0 – 6.0	7.0 – 9.0	2.70 – 4.0	
Mean ± SD.	5.33 ± 0.58	8.0 ± 1.0	3.23 ± 0.68	
Median	5.0	8.0	3.0	0.001
Sig.bet,grop.	p_1=0.006*,p_2=0.016*,p_3<0.001*			

p1: p value for comparing between neutral group and acidic group. p2: p value for comparing between neutral group and alkaline group. p3: p value for comparing between alkaline group and acidic group

Table 3. Comparison between the different groups according to current (MA) after 30 days (: Statistically significant at p ≤ 0.05)*

30 days	Neutral (n=3)	Acidic (n=3)	Alkaline (n=3)	p
Current(MA)				
Min. – Max.	9.0 – 10.14	14.07 – 15.0	8.03 – 9.07	<0.001*
Mean ± SD.	9.43 ± 0.62	14.69 ± 0.54	8.70 ± 0.58	
Median	9.15	15.0	9.0	
Sig.bet,grop.	p_1<0.001*,p_2=0.174,p_3<0.001*			

p1 : p value for comparing between neutral group and acidic group. p2 : p value for comparing between neutral group and alkaline group. p3 : p value for comparing between alkaline group and acidic group

*Table 4. Comparison between the two periods according to current (MA) in each group (*Statistically significant at p ≤ 0.05)*

Current (MA)	7 days (n=3)	30 days (n=3)	p
Neutral			
Min. – Max.	5.0 – 6.0	9.0 – 10.14	0.001*
Mean ± SD.	5.33 ± 0.58	9.43 ± 0.62	
Median	5.0	9.15	
Acidic			
Min. – Max.	7.0 – 9.0	14.07 – 15.0	0.001*
Mean ± SD.	8.0 ± 1.0	14.69 ± 0.54	
Median	8.0	15.0	
Alkaline			
Min. – Max	2.70 – 4.0	8.03 – 9.07	<0.001
Mean ± SD.	3.23 ± 0.68	8.70 ± 0.58	
Median	3.0	9.0	

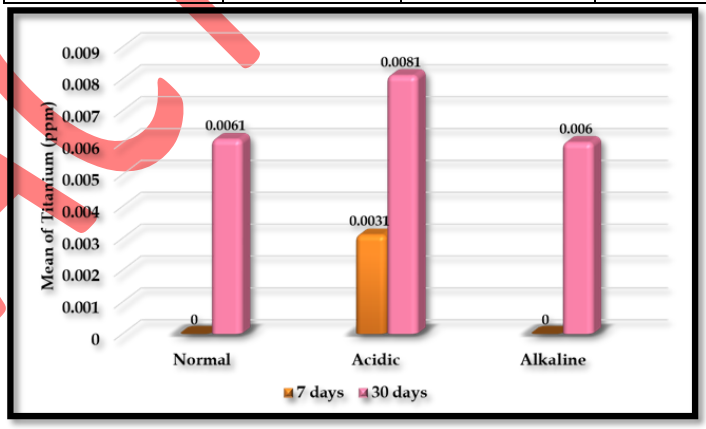

Figure 4. Comparison between the different groups according to current (MA) after 7 and 30 days

DISSCUSION

In this study, measured of the galvanic current between titanium and cobalt chromium was done using titanium as cathode and chromium as anode because when dissimilar metal come in contact with each other in presence electrolyte fluid, the less noble alloysform use as anode and the other use as cathode. And the test made when the sample immersed in artificial saliva because electrolytes (saliva or oral fluid) resulting flow of electric current between them. In this study, showed that in 30days the concentration

of metallic ions released in acidic Ph was the most, this may due to breakdown of the passive layer that formed at short immersed time, that coincide with Nakagawa et al., [7] who found that in acidic conditions with different fluoride concentration, could lead to the destruction of the passive film on titanium surfaces. When the potential of the coupled metal decreases, the galvanic current and thus the metal ion release increases. The decrease in potential can be due to the nature of the galvanic couple but also can be caused by the mechanical removal of the passive film, for example, fretting conditions (i.e., fretting-corrosion conditions), which would lead to an acceleration of the corrosion rate of the material [22]. On the other hand, titanium stability is extremely dependent on the solution chemistry and coupled material, generating a high metal ion released in an acidic solution and when coupled to another titanium alloy, that clearly increases the amount of released ions, which may cause of biologic effects, and it has been reported as the one of the possible causes of implant failure after initial success [23]. Zhoid et al. [24] mentioned that a galvanic current greater than 20 mA was sufficient to cause sharp pain. The currentgenerated ions released from the corrosion process could also cause inflammatory and cytotoxic effects, mutagenicity and allergies. [25] The highest current of 0.638 mA found during the interactions tested in this study was inside the limit cited by Zhoid et al. [24] and thus would not cause deleterious effects. Although the occurrence of galvanic corrosion was detected, the interaction was not a risk effect since the coupled materials established a passive state in a short time, generating galvanic currents that were very low or close to zero.

CONCLUSION

Within the limitation of this in vitro study, there where galvanic current between titanium dental implant when coupled with cobalt chrome bar and it significantly increased with the time especially when immersed in acidic media.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

REFERENCES

1. Balkin, B.E. Implant dentistry: Historical overview with current perspective. Int. J. Oral Implantol. 1988, 5, 27–28.
2. Manan, N. S.; Harun, W. S. W.; Shri, D. N. A.; Ghani, S. A. C.; Kurniawan, T.; Ismail, M. H.; Ibrahim, M. H. I. Study of corrosion in biocompatible.
3. Moreno, J. M. C. Vasilescu, E.; Drob, P.; Osiceanu, P.; Vasilescu, C.; Drob, S. I.; Popa, M. Surface and electrochemical characterization of a new ternary titanium based alloy behaviour in electrolytes of varying pH. Corrosion Science, v. 77, 2013.
4. Silva-Bermudez, P.; Rodil, S. E. Na overview of protein adsorption on metal oxide coatings for biomedical implants. Surface & Coatings Technology, v. 233, 2013.
5. Revathi, A.; Magesh, S.; Balla, V. K.; Das, M.; Manivasagam, G. Current advances in enhancement of wear and corrosion resistance of titanium alloys: a review. Materials Technology, 2016.
6. Apaza-Bedoya, K.; Tarce, M.; Benfatti, C. A. M.; Henriques, B.; Mathew, M. T.; Teughels, W. Souza, J. C. M. Synergistic interactions between corrosion and wear at titanium-based dental implant connections: A scoping review. Journal of Periodontal Research, v. 52(6), 2017.
7. Nakagawa, M.; Matsuya, S.; Shiraishi, T.; Ohta, M. Effect of fluoride concentration and pH on corrosion behavior of titanium for dental use. J. Dent. Res. 1999, 78, 1568–1572.
8. ToumelinChemla, F.; Rouelle, F.; Burdairon, G. Corrosive properties of fluoride-containing odontologic gels against titanium. J. Dent. 1996, 24, 109–115.
9. Olmedo, D.; Fernandez, M.M.; Guglielmotti, M.B.; Cabrini, R.L. Macrophages related to dental implant failure. Implant Dent. 2003, 12, 75–80.

10. Guglielmotti, M.B.; Cabrini, R.L. Evaluación biológica de implantes dentales fracasados. Rev. Asoc. Odontol. Argent.1997, 85, 313–317.
11. Brunette DM, Tengvall P, Textor M, Thomsen P, (Eds.). Titanium in Medicine, Springer-Verlag, ISBN 3540669361, Berlin, Germany.
12. Chaturvedi, T. P. An overview of the corrosion aspect of dental implants (titanium and its alloys). Indian Journal for Dental Research, v. 20(1), 2009.
13. Bhola, R.; Bhola, S. M.; Mishra, B.; Olson, D. Corrosion in titanium dental implants/prostheses – a review. Trends in Biomaterials and Artificial Organs, v. 25(1), 2011.
14. L.N. Miotto, L.M. Fais, A.L. Ribeiro and L.G. Vaz, J. Prosthet. Dent., 116 (2016) 102.
15. S. Prasad, M. Ehrensberger, M.P. Gibson, H. Kim and E.A.Monaco, J. Oral Biosci., 57 (2015) 192.
16. Foti, B.; Tavitian, P.; Tosello, A.; Bonfil, J.J.; Franquin, J.C. Polymetallism and osseointegration in oral implantology: A pilot study on primate. J. Oral Rehabil. 1999, 26, 495–502.
17. H. Zohdi, M. Emami and H.R. Shahverdi, InTech., 1 (2012) 157.
18. J.C.M. Souza, S.L. Barbosa, E. Ariza, J.P. Celis and L.A. Rocha, Wear. Nano-scale modification of titanium implant surfaces to enhance osseointegration 292 (2012) 82.
19. N.S. Manam, W.S.W. Harun, D.N.A. Shri, S.A.C. Ghani, T. Kurniawan, M.H. Ismail and M. H. I. Ibrahim. Study of corrosion in biocompatible metals for implants: A review. J. Alloys Compd., 701 (2017) 698.
20. I. Golvano, I. Garcia, A. Conde, W. Tato and A. Aginagald, J. Mech. Behav. Tribocorrosion under galvanic interaction of Ti6Al4V and NiCr implant alloys. Biomed. Mater, 49 (2015)186.
21. Sutow, E.J.; Wayne, W.A.; Taylor, J.C.; Hall, G.C. In vivo galvanic currents of intermittently contacting dental amalgam and other metallic restorations. Dent. Mater. 2004, 20, 823–831.
22. Ana Mellado-Valero, Anna Igual Muñoz , Virginia Guiñón Pina and Ma Fernanda Sola-Ruiz. Electrochemical Behaviour and Galvanic Effectsof Titanium Implants Coupled to Metallic Suprastructures in Artificial Saliva. J. Materials 2018, 11, 171; doi:10.3390.
23. Olmedo, D.G.; Tasat, D.R.; Duffo, G.; Guglielmotti, M.B.; Cabrini, R.L. The issue of corrosion in dental implants: A review. Acta Odontol. Latinoam. 2009.
24. H. Zohdi, M. Emami and H.R. Shahverdi. Galvanic Corrosion Behavior of Dental Alloys. In Tech., 1 (2012) 157.
25. N.S. Manam, W.S.W. Harun, D.N.A. Shri, S.A.C. Ghani, T. Kurniawan, M.H. Ismail and M. H. I. Ibrahim. Study of corrosion in biocompatible metals for implants: A review. J. Alloys Compd., 701 (2017) 698.