https://doi.org/10.4047/jap.2021.13.1.65

Effect of fluid contamination on reverse torque values in implant-abutment connections under oral conditions

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PURPOSE. Implant mechanical complications, including screw loosening, can influence dental implant success. It has been shown that torque values are affected by contamination occurred in implant-abutment (I/A) interface. This study aimed to examine the effects of blood, saliva, fluoride and chlorhexidine contamination on reverse torque values (RTVs) of abutment screws in oral conditions. **MATERIALS AND METHODS.** 50 fixtures were mounted into the stainless-steel holders and divided into five groups (n = 10). Except control group (NC), fixture screw holes in other groups were contaminated with chlorhexidine (CG), saliva (SG), blood (BG), or fluoride (FG). Abutment screws were tightened with a digital torque meter. I/A assemblies were subjected to thermocycling and cyclic loading. The mean RTVs were recorded and data were analyzed with one-way ANOVA and Tukey test. **RESULTS.** Except for specimens in SG (20.56 ± 1.33), other specimens in BG (21.11 ± 1.54), CG (22.89 ± 1.1) and FG (24.00 ± 1.12) displayed significantly higher RTVs compared to NC (19.00 ± 1.87). The highest RTVs were detected in CG and FG. **CONCLUSION.** The obtained data robustly suggest that RTVs were significantly affected by fluid contaminations. Specimens in FG and CG displayed the highest RTVs. Therefore, clinicians should have enough knowledge about probable contaminations in I/A interface in order to manage them during clinical procedure and to inform patients about using oral care products. [J Adv Prosthodont 2021;13:65-70]

KEYWORDS
Abutment screw loosening; Fluid contamination; Blood; Saliva; Fluoride; Chlorhexidine

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Received September 15, 2020 / **Last Revision** December 5, 2020 / **Accepted** December 30, 2020

This study supported by Tehran University of Medical Sciences (grant no: 97-02-69-38978).

INTRODUCTION

Evidence indicates that implant treatment gives a considerable improvement in patients' quality of life.[1,2] Despite high success rate in dental implant treatments, mechanical complications such as screw loosening (the most common) still exist.[3] The screw loosening happens when the clamping forces be-

https://doi.org/10.4047/jap.2021.13.1.65

come less than the joint separating forces.[4] When a screw is tightened by torque application, it elongates and creates tension (preload). Several factors may affect preload, including screw design and materials, applied torque magnitude,[5] torque delivery system,[6] and environmental factors (presence of fluid contaminations and lubrication).[7,8] Screw loosening would result in different clinical dilemmas including formation of microgap between implant components, displacement of the prosthesis, decreased prosthetic function, and inflammation.[9,10] Therefore, this problem would result in the increased number of referrals for implant maintenance, which is extremely time-consuming and also inconvenient for patients.[11] The implant screw hole may become contaminated by different compounds at the time of delivery or during functional activity.[12-14] However, few studies have considered the role of fluid contamination on reverse torque values of the abutment screw.[15-20] The common limitations of the performed researches were the limited number of contaminants and lacking simulation of oral conditions. Therefore, this study aimed to evaluate the effect of blood, saliva, fluoride, and chlorhexidine contamination on torque values of abutment screws in oral simulated conditions. The null hypothesis was that there is no statistically significant difference in RTVs among the contamination groups and the control group.

MATERIALS AND METHODS

Power analysis was performed with PASS11 software for ANOVA. Considering the obtained results (5 study groups and standard deviation of 1.41), the power was greater than 80%. In this *in vitro* experimental study, 50 fixtures (Grade 4 Titanium, 4.5 × 10 mm bone level implants, Implantium, Dentium Co., Seoul, Korea) were mounted onto the stainless-steel holders according to ISO 14801. Specimens were divided into five groups (n = 10) (Table 1). Contaminants were applied by a pipette until the screw access hole of the implant fixture was completely filled. Saliva sample was collected from a donor at rest. Also, blood sample was obtained from the same donor (from the fingertip by a lancet). The protocol was approved by Ethical Committee of Tehran University of Medical Sciences prior to data collection. Abutments (Dual abutment [hex], 4.5 mm diameter with 1.5 mm gingival height, Implantium, Dentium Co., Seoul, Korea) were tightened to fixtures (30 Ncm) by a digital torque meter (TQ-8800, Lutron Electronic Enterprise Co., Taipei, Taiwan); the second torque was applied 15 minutes later. I/A assemblies were subjected to thermocycling (5 - 55°C, 5,000 cycles, 60 seconds dwell time) and cyclic loading (500,000 cycles, 100 N, and 1 Hertz). To prevent abutment deformation and to ensure accurate load transmission to I/A interface, a cast coping (Damcast Nb, Yadent New-materials Co., Zhengzhou, China) was used during cyclic loading (Fig. 1). The mean RTVs in each group were calculated. Homogeneity of variances was evaluated by the Levene test (P = .617). The results were statistically analyzed using 1-way ANOVA. The Tukey honestly significant difference (HSD) test was applied to compare test groups. Statistical significance was set at P < .05.

Table 1. Information related to test groups

Groups	Description	Source
NC	Without contamination	
BG	Blood	Capillary blood
SG	Saliva	Fresh saliva
CG	Chlorhexidine 0.2%	Donyaye Behdasht Pharmaceutical Co.
FG	Fluoride 0.2%	Donyaye Behdasht Pharmaceutical Co.

NC, Noncontaminated; BG, Contaminated with blood; SG, Contaminated with saliva; CG, Contaminated with chlorhexidine; FG, Contaminated with fluoride.

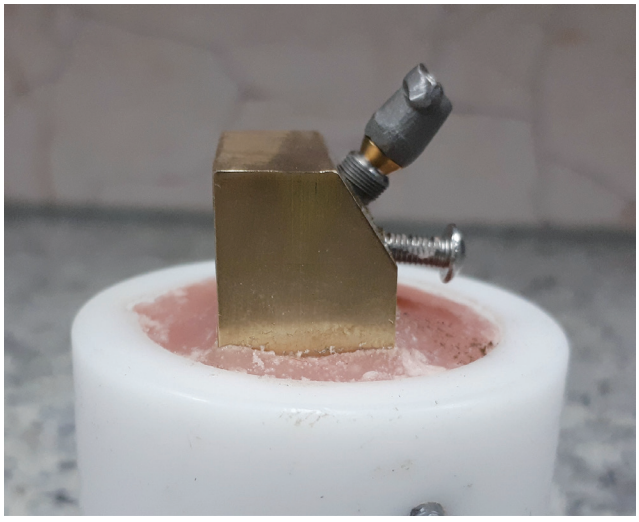

Fig. 1. Mounted specimen prepared for cyclic loading.

RESULTS

One-way ANOVA revealed significant differences among the test groups ($P < .001$). The mean RTVs for the specimens in each group are presented in Table 2. For all groups, the RTVs were lower than Tightening torque values (TTVs=30 Ncm). Except for specimens in SG ($P = .16$), other specimens in BG ($P = .03$), CG ($P < .001$), and FG ($P < .001$) displayed significantly higher RTVs compared to NC. The greatest decrease in RTVs was seen in NC and SG. The highest RTVs were detected in FG and CG, which were not significantly different ($P = .48$). No statistically significant difference was found for BG compared with SG ($P = .92$) or CG ($P = .08$).

Table 2. Mean RTVs and SDs of all test groups (Ncm)

Groups	Min	Max	Mean ± SD
NC	17.00	23.00	19.00 ± 1.87[a]
BG	19.00	23.00	21.11 ± 1.54[bc]
SG	19.00	23.00	20.56 ± 1.33[ab]
CG	23.00	25.00	22.89 ± 1.17[ce]
FG	23.00	26.00	24.00 ± 1.12[e]

NC, Noncontaminated; CG, Contaminated with chlorhexidine; SG, Contaminated with saliva; BG, Contaminated with blood; FG, Contaminated with fluoride. Same superscript letters show mean values with no statistically significant difference between groups ($P > .05$).

DISCUSSION

The aim of this study was to investigate whether the contamination of abutment screws with blood, saliva, fluoride, or chlorhexidine would affect the RTVs. Based on the obtained results, the null hypothesis was rejected. RTVs in all groups were lower than TTVs, which was in agreement with previous studies.[4,10,11,16,17] External forces that overtake the clamping forces and settling effect (relaxation embedment) are the main factors of decreased RTVs. The lowest RTVs were seen in NC followed by SG, although it was not significant. FG showed the highest RTVs, which had no significant difference from CG. On the other hand, BG results were not statistically different from SG but marginally significantly different from CG. Preload has a prominent role in I/A joint stability and if it reduces during clinical function because of contamination, the connection stability would be compromised due to screw loosening. Increasing the applied torque and decreasing the coefficient of friction can be used to increase the resulting preload.[7,8] On the other hand, lowering coefficient of friction would result in higher yield strength, which is important in obtained preload. Although dry conditions are normally recommended when torquing the abutment, contamination of I/A interface is an inevitable process during clinical sessions or subsequent functional activities. Furthermore, it has been shown that contaminations can be influential as a lubricant on the coefficient of friction.[5]

In the present study, the mean RTVs in SG were not statistically different from NC. This result is similar to the findings of Gumus *et al*.,[16] Al Raffee *et al*.,[12] Norton[14] and Jalali *et al*.[20] In contrast, Tzenakis *et al*.,[5] Nigro *et al*.[19] and Ghanbarzadeh *et al*.[15] stated that saliva as a lubricant increased the torque values. Even though, Tzenakis *et al*. applied prosthetic gold screws and Nigro *et al*. tested TorqTite screws of zirconia abutments, which distinctly affect generated preload. Also, the specimens did not undergo simulation tests in the recent studies. Nigro *et al*.[19] stated that less torque loss due to existing humid media in I/A connection could be occurred as the result of the following hypotheses: elimination of internal shear forces to a large extent, uneven

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friction during unscrewing, and prevention of settling effect. According to Jörn *et al*.'s[8] study based on FEA, although saliva would result in reduced friction within I/A assembly and subsequent higher preload, due to detrimental effect on stresses in the implant components, it should be avoided. In Koosha *et al*.'s[17] research, specimens in SG declared the least RTVs when compared with NC; the only difference between this study and the present one was the simulation of oral condition.

Specimens in CG displayed higher RTVs compared with NC, which may be due to the lubricating feature of chlorhexidine. Lubrication between the abutment screw and their mating part in fixture affects the preload developed in the implant complex. It was delineated that the preload value within the target range (60 - 75% of the yield strength of the abutment screw material) was almost 54% for the well-lubricated environment and only 0.02% for the dry environment.[7] This result was similar to the obtained findings by Koosha *et al*.,[17] in which applying chlorhexidine 0.2% had been recommended to decrease screw loosening beside its antimicrobial performance. On the other hand, Micarelli *et al.*[18] and Gumus *et al*.[16] found that contamination with chlorhexidine has no statistically significant effect on RTVs. Variations in the form (gel versus liquid) and concentration of contamination[21] may be assigned for different results of the previous studies.

Wetting the fixture screw hole with blood during abutment insertion is common especially in bone-level implants. In the current study, the mean RTVs in BG were higher than those in NC. Contrary to this outcome, Koosha *et al*.[17] and Jalali *et al*.[20] reported that blood contamination did not lead in different results compared with control group. The findings of Gumus *et al*.[16] suggested that the accumulation of blood on the surface of abutment screw could have a negative effect on torque value by forming a biofilm. Also, it has shown that viscosity of blood may have an important role in the torque value reduction after contamination. Therefore, the blood source and time delay when fastening the abutments in fixture screw holes may affect the viscosity and may cause different results in studies. In the present study, capillary blood was applied before coagulation occurred.

The specimens in FG showed significantly higher RTVs than those in NC did, which was in line with Duarte *et al*.'s[13] results. They explained that a corrosion layer would be sedimented following electrochemical reaction in I/A connection due to the presence of fluoride. This layer could be the result of less torque loss in I/A assembly. Fluoride containing oral care products such as commercial dentifrices, topical gels/varnishes, and mouthwashes are applied by patients or through dental services. Micromovements may occur in I/A interface during functional activity and penetration of oral fluids including fluoride would be taken place. In Zavanelli *et al*.'s[22] study, both Cp Ti and Ti6Al4V revealed the worst fatigue corrosion behavior in the fluoridated artificial saliva solution. In addition, Souza *et al*.[23] denoted that with increasing fluoride concentration, Titanium degradation would be increased as well. Koosha *et al*.[17] reported lower RTVs for FG in a similar study; the main difference was lack of cyclic loading and less thermal cycles. It seems that simulating oral condition and spending more time in the current study are two effective factors in different results.

Although thermal cycling and cyclic loading were performed to better simulate oral environment in the present study, it should be considered that I/A interface can be contaminated with more than one of the mentioned contaminants simultaneously. Also, contamination could occur after torquing the abutments during functional period; therefore, the method of contamination could be different, which can be considered in further studies. Moreover, it is recommended to design *in vivo* studies to investigate the effect of chlorhexidine on RTVs and also to monitor the implants in patients who are using fluoride containing oral care products.

CONCLUSION

Although the contamination protocol in this *in vitro* study may not fully reflect an actual clinical condition, the obtained results provide clinicians with new insight into the effect of probable fluid contaminations in I/A interface. Within the limitations of this *in vitro* study, it was concluded that contrary to NC and SG results, the highest RTVs were detected in the FG

and CG. According to the results, irrigation of the I/A connection with CHX before torqueing the abutment at delivery appointment would be recommended, and saliva contamination should be avoided.

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