



# Effect of Blood and Saliva Contamination of the Implant-Abutment Interface on the Amount of Preload

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## Abstract

**Background and Objectives:** Screw loosening after implant treatment is due to several factors including reduction in optimal preload. This study aimed to assess the effect of blood and saliva contamination of the implant-abutment interface on the amount of preload.

**Materials and Methods:** In this *in vitro* experimental study, 18 cement-retained base metal crowns were fabricated on the same number of abutments with 45° angle relative to the horizontal line using the conventional casting method. The samples were randomly divided into three groups of C, B and S (n=6). The abutments with titanium screws were torques to 30 Ncm on fixtures. After five minutes, the screws were tightened again to the same torque level. After 10 minutes, maximum detorque value was measured. In group C, the abutment screws were torqued again to 30 Ncm. In groups B and S, implant-abutment interface was contaminated with blood and saliva, respectively after unscrewing and then the screws were tightened again to 30 Ncm. After cyclic loading (one million cycles), maximum detorque value was measured. Data were analyzed using one-way ANOVA.

**Results:** A significant reduction occurred in detorque value in all three groups after cyclic loading compared to the baseline detorque value (P<0.001) but the difference among the three groups was not significant (P=0.221).

**Conclusion:** Within the limitations of this study, the results showed that blood or saliva contamination of the implant-abutment interface had no significant effect on preload.

**Keywords:** Abutment; Blood; Implant; Preload; Saliva; Screw

## Introduction

Currently, dental implants are commonly used for replacement of the lost teeth, full dental rehabilitation and even prosthetic maxillofacial reconstruction with predictable success rate [1]. This treatment modality is associated with significantly higher patient satisfaction compared to tooth-supported fixed or removable dentures and enhances the quality of life of patients [2].

In use of screw for attachment of abutment to fixture, the screw is torqued by a torque wrench to 20 to 30 Ncm [3]. This type of attachment is referred to as screw joint [4]. Following abutment screw tightening, load is applied to three interfaces namely the

screw-abutment interface, screw-fixture interface and abutment-fixture interface; the load applied to the latter interface is referred to as the clamping force [5]. Screw tightening engages the screw at the abutment and fixture interfaces and results in its elongation and subsequent creation of tension in the screw. This tension is referred to as the preload [6]. The torque applied to screw aims to generate preload tension and results in clamping of components [7-9]. This is often achieved by torquing the screw for maximum elongation while maintaining it below the fatigue threshold [3]. The amount of preload has a direct correlation with the amount of torque applied to the screw [4]. Over 90% of the torque applied for screw tightening is used to overcome friction and only 10% is used for actual torquing [10]. Thus, reduction of friction between metal threads and the opposing surfaces may enhance screw rotation and subsequently increase the preload. Optimal preload must be high

enough to prevent screw loosening following the application of functional loads [7-9]. On the other hand, this value should not exceed the fracture threshold of screw threads or abutment itself [11].

Several factors may affect the preload such as the modulus of elasticity of the screw, quality of the opposing surfaces at the joint, friction coefficient of surfaces, lubrication, frequency of torque application and adaptation of fixture hexagon to the abutment [6]. In order to effectively create preload, the screw should be tightened as recommended by the manufacturer, unscrewed after a couple of minutes and tightened again as recommended. After five minutes, the screw should be tightened for the third time to compensate for any reduction in preload or preload rebound [12]. The higher the preload, the higher the resistance of screw to loosening and the more stable the joint would be. Thus, resistance against functional loads would increase. Following reduction of preload to critical threshold, external forces quickly erode the residual preload and cause joint interface opening and subsequent screw loosening and joint failure [3]. Screw loosening is a common problem occurring in about 6% of implant-supported restorations [12]. Screw loosening may occur due to inadequate torque [4,7,8,11,13], component design, implant design, the amount of stress applied, length of cantilever, crown height, height and depth of anti-rotation part, platform dimensions, and inappropriate adaptation of components and machined surfaces [11,12,14].

In titanium abutments, optimal preload can be achieved when components are precisely attached. However, in case of inappropriate attachment or contamination of the interface with debris, the achievable amount of preload may significantly decrease [15]. Even a small amount of misfit can change the preload-torque relationship. Moreover, when preload is used to assemble the components with poor adaptation, fatigue protection is lost because the external forces increase tension in the screw instead of being used at the interface [15].

Cyclic loading is often used *in vitro* to simulate the loads applied to crown-abutment-fixture in function. Dynamic load application in the range of 0-100 N with 1.25 Hz frequency simulates chewing *in vivo* and one million cycles correspond to one year of clinical service [16]. For calculation of preload, a strain gauge can be used. However, it cannot be subjected to cyclic loading. Another method for calculation of preload is to assess the amount of reverse torque required for detorquing of a screw tightened by a certain amount of torque. The difference between the final detorque value and the primary torque or detorque indicates changes in the amount of preload. The torque required for tightening of the abutment screw can be applied by a hand-held screw driver or mechanical torque limiting devices. However, in these methods, the torque or detorque value cannot be measured and recorded. An electronic torque meter enables continuous and quantitative monitoring of the amount of torque applied.

In fabrication of implant prosthesis, after opening the heal-

ing cap or the abutment, the area is rinsed and then dried using sterile cotton pellet or gauze and air sprayed before tightening of the temporary abutment. However, in some cases, rinsing and drying are ineffective because the area cannot be isolated and the blood or saliva contaminates the mandibular molar or other submerged fixtures and attempts for further cleaning of the area triggers further bleeding into the fixture. It is particularly seen in cases where the fixture is placed subcrestally since the gingival tissue proliferates into the fixture. This concern also exists for bone level abutments. The effect of saliva at the abutment-fixture interface on the fit of components and preload has been previously evaluated but no comparison has been made between contamination of this area with saliva and blood and isolated, dry interface.

Considering the existing concerns regarding the outcome of blood and saliva contamination of the interface, this study aimed to assess the effect of saliva and blood contamination of the abutment-fixture interface at the time of abutment screw tightening on the amount of preload after cyclic loading. The null hypothesis was that the amount of final preload, determined by the detorque value, would be the same in all three groups of dry, saliva-contaminated and blood-contaminated interface.

## Materials and Methods

In this study, sample size was calculated to be six samples according to a previous study by Aboyoussef et al, [17] and assuming  $\alpha=0.05$ ,  $\beta=0.2$ , mean standard deviation of 6.05 and minimum difference of 22.8 using Minitab software.

Medium-size fixture and abutment from the Implantium system were selected; 4.3 mm diameter implants with 4.5 mm diameter and 10 mm length platform (FX 43100) and abutments with 4.5 mm diameter, 5.5 mm length and 1 mm gingival height (DAB4510HL) were used in this study (Implantium®; Dentium Inc., Seoul, Korea). An electronic torque meter (Lutron Electronic Enterprise Co., Taipei, Taiwan) was also used with 0.01 Ncm accuracy in high resolution mode and 0.1 Ncm accuracy in low resolution mode. A screw driver with 21 mm length (XHD 21, Implantium) was attached to the mechanical head of the device and tightened.

## Mounting of Implants in Acrylic Resin

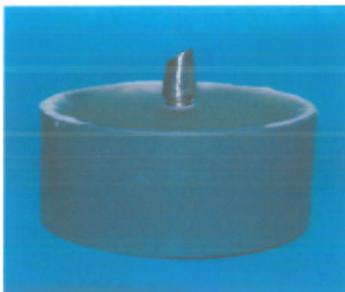
The implants were mounted using a ring designed for this purpose and a surveyor so that the implants were mounted right at the center of the ring. The abutment-fixture was fixed at the center with appropriate height, and acrylic resin was then incrementally applied around it. The fixture margin was positioned 1 mm above the ring and mounted using auto-polymerizing acrylic resin (Dentsply Inc., York, USA). After completion of mounting, only 1 mm of the fixture was above the acrylic surface.

## Fabrication of Crown on The Abutment

To standardize the crowns, abutment-fixture assembly was mounted in acrylic perpendicular to the horizontal line and then

a burnout cylinder was placed on the abutment and the height of the upper surface of the abutment was marked on it. A section was made at this point with 45° angle relative to the horizontal line (so that the horizontal component of load applied to the crown would simulate off-axial forces while vertical component of load would simulate vertical loads applied to the longitudinal axis of implant). Crown was formed on the burnout cylinder with 45° angle in the occlusal surface relative to the horizontal line using pattern resin (GC Corporation, Tokyo, Japan) by a paint brush. Thus, all crowns had the same length, shape and angle relative to the horizontal line.

The pattern resin was gently removed from the abutment and sprued. After investing with investment gypsum (Hinrivest KB; Ernst Hinrichs GmbH, Goslar, Germany), it was placed in the burnout furnace and cast (Aalba Dent Inc. Fairfield, Vira Bond V California, USA). Crowns were then removed from the furnace and sandblasted with aluminum oxide particles with 125 μ diameter (Koraks, BEGO, and Germany) and 0.28 MPa pressure for 15 seconds from 10 mm distance [18]. The excess material was removed and sharp points were beveled after casting using a metal reamer (Dentium, Seoul, Korea). The crowns were tried on the abutments (Figure 1). Of 18 fabricated crowns, four did not have adequate retention and resistance and showed some degrees of rotation on the abutment. They were replaced with new fabricated crowns with perfect adaptation to the abutment and no visible gap. Examination by an explorer revealed no gap. The fabricated crowns had an anti-rotation part. To ensure no rotation of crown on the abutment, a line was drawn on the abutment and crown with a black marker to ensure no change in the position of crown relative to the abutment (Figure 2).



**Figure 1:** Completed Crown Assembled on the Abutment-Fixture.



**Figure 2:** Line Drawn to Ensure Correct Position of Crown on the Abutment.

## Determination of Primary Torque and Primary Detorque Values

Using a table of random numbers, the samples were divided into three groups.

Group one served as the control group (C).

Group two (B) was subjected to blood contamination.

Group three (S) was subjected to saliva contamination.

The following steps were similarly performed for all groups. At time zero, the abutment screw was torqued to 30 Ncm by the abutment screwdriver attached to the electronic torque meter. For better control, torque meter was held by one hand and the ring containing the sample was held by the other hand. The ring was turned to tighten the screw. The shape of the screw involved with the screwdriver was hexagonal. After five minutes, the screw was torqued to 30 Ncm to compensate for the settling effect.

Fifteen minutes after the time zero, the abutment screw was detorqued and the maximum reverse torque prior to loosening of the abutment screw was recorded. The sensitivity of electronic torque meter was adjusted to 0.01Ncm accuracy with high resolution mode. Next, in group C, the abutment screw was torqued to 30 Ncm and tightened. In group B, after detorquing, the abutment screw was completely loosened and the abutment was separated from the fixture. One drop of venous blood, collected from a volunteer, was then placed at the fixture opening (n=6 in group B). After 2.5 minutes, the abutment was placed back on the fixture and the abutment screw was torqued to 30 Ncm. The same steps were followed in group S except that saliva, collected from a 32-year-old male with mucous saliva after 20 minutes of exercise, was applied at the fixture opening. After 2.5 minutes, the abutment screw was torqued to 30 Ncm.

## Cyclic Loading

The abutment screw opening was obstructed by a small cotton pellet and the crowns were cemented using small amount of temporary cement (Temp Bond NE Kerr; Kerr Hawe, Orang, CA USA). After applying finger pressure for 10 seconds, 6 kg load for 10 minutes was applied to the crown and excess cement was removed by an explorer [19]. The fixture-abutment-crown assembly was placed in cyclic loading device and subjected to 70 N loads for one million cycles corresponding to one year of clinical service [15]. To control for the position of crown on the abutment, the device was stopped after every 100,000 cycles and alignment of crown and abutment was ensured (by the line drawn earlier). Also, complete seating of crown on the abutment and their adaptation was checked using an explorer and tactile sense of the operator. Displacement or rotation of crown on the abutment did not occur in any sample.

## Determination of Final Detorque Value

After cyclic loading, metal crowns were gently removed

from the abutments by hand. The abutment screw opening was cleaned from excess cement and cotton pellet using an explorer and then maximum detorque value prior to abutment screw loosening was measured by an electronic torque meter. The detorque values displayed on the monitor of electronic torque meter were Analyzed Using One-Way ANOVA.

## Results

As shown in Table 1, the maximum and minimum detorque values before cyclic loading were 28.40 Ncm and 24.70 Ncm, respectively with a mean value of 26.4±1.19 Ncm in the control group. After cyclic loading, the mean detorque value was 15.26±2.15 Ncm with a maximum value of 18.6 Ncm and minimum value of 12.4 Ncm. The mean reduction in detorque value was 11.13 Ncm, which was 42% of the primary detorque value in the control group.

Peak of Detorque (Ncm) after 10 <sup>6</sup> cycles	Third Torque	Contamination	Peak of Detorque (Ncm) at 15 min.	Second Torque (30 Ncm) at 5 min.	First Torque (30 Ncm) at 0 min.	Groups
15.4		-	26.4	+	+	<b>C1 (Control)</b>
14.7	+	-	25.9	+	+	<b>C2</b>
16.6	+	-	26.6	+	+	<b>C3</b>
18.6	+	-	24.7	+	+	<b>C4</b>
13.9	+	-	28.4	+	+	<b>C5</b>
12.4	+	-	26.4	+	+	<b>C6</b>
10.9	+	+	26.4	+	+	<b>B1 (Blood)</b>
10.1	+	+	25.1	+	+	<b>B2</b>
10.8	+	+	26.1	+	+	<b>B3</b>
15.5	+	+	27.0	+	+	<b>B4</b>
12.2	+	+	26.5	+	+	<b>B5</b>
16.4	+	+	27.5	+	+	<b>B6</b>
14.0	+	+	24.3	+	+	<b>S1 (Saliva)</b>
12.1	+	+	24.7	+	+	<b>S2</b>
13.1	+	+	26.9	+	+	<b>S3</b>
15.4	+	+	23.6	+	+	<b>S4</b>
9.4	+	+	26.9	+	+	<b>S5</b>
16.3	+	+	28.2	+	+	<b>S6</b>

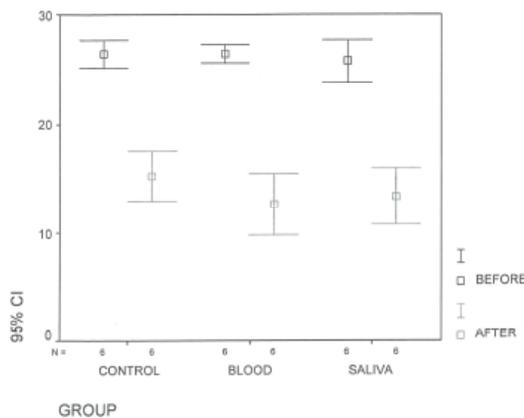
**Table 1:** Detorque value in the samples in the three groups.

In group B, prior to cyclic loading, the mean detorque value was 26.43±0.81 Ncm with a maximum value of 27.50 Ncm and minimum value of 25.10 Ncm. After cyclic loading, the mean detorque value was 12.65±2.65 Ncm (range 10.10 to 16.4 Ncm). In this group, reduction in final detorque value was 13.78 Ncm, which was 52% of the primary value. In group S, the mean primary detorque value was 27.76±1.81 Ncm (range 23.6 to 28.20 Ncm). After cyclic loading, detorque value was 13.38±2.47 (range 9.4 to 16.30 Ncm). The mean reduction in detorque value in this group

after cyclic loading was 12.38 Ncm, equal to 48.5% of the primary value. As shown in Table 2, before cyclic loading, the greatest difference between the maximum and minimum detorque values was noted in group S (Standard Deviation of 1.8) and the minimum difference was noted in group B (Standard Deviation of 0.81) but after cyclic loading, the greatest difference in maximum and minimum detorque values was noted in group B (Standard Deviation of 2.6) and the lowest was noted in group C (Standard Deviation of 2.1) (Figure 3).

Group	Time (Cyclic Loading)	Minimum	Maximum	Mean	Standard Deviation
Control	Before	24.70	28.40	26.4000	1.19833
	After	12.40	18.60	15.2667	2.15932
Blood	Before	25.10	27.50	26.4333	81894
	After	10.10	16.40	12.6500	2.65989
Saliva	Before	23.60	28.20	25.7	1.81512
	After	9.40	16.30	13.3833	2.47177

**Table 2:** Mean standard deviation of detorque value in the three groups.



**Figure 3:** Error bar of the mean and 95% confidence interval of the detorque value in the three groups.

Maximum detorque value prior to cyclic loading (28.4 Ncm) was noted in group C while minimum value (23.6 Ncm) was noted in group S. After cyclic loading, maximum detorque value was noted in group C (12.4 Ncm) and minimum value was noted in group S (9.4 Ncm).

In general, the highest detorque value was noted in group C before cyclic loading (28.4 Ncm) and the lowest was noted in group S after cyclic loading (9.4 Ncm). All samples showed a reduction in detorque value after cyclic loading; this reduction was higher than 50% of the primary value. According to repeated measures ANOVA, the effect of within-subjects factor showed that the amount of torque required for loosening of the abutment screw before and after cyclic loading was significantly different ( $P < 0.001$ ). The between-subject factor analysis showed that the contamination factor (blood/saliva) at the fixture-abutment interface at the time of tightening of the abutment screw had no significant effect on the detorque value required for loosening of the abutment screw ( $P = 0.221$ ).

## Discussion

This study assessed the effect of blood and saliva contamination of the implant-abutment interface on the amount of preload.

The results showed that the detorque value of abutment screw significantly decreased after cyclic loading. The highest detorque value after cyclic loading was recorded in the control group and the lowest value was noted in blood-contamination group. However, the difference in this respect was not significant among the three groups. Several factors affect the preload such as modulus of elasticity of the screw, the quality of surfaces in contact with each other, modulus of elasticity, lubrication, frequency of torque application and the adaptation of fixture and abutment hexagon [6].

Preload can be measured by a strain gauge or by assessing the difference between the detorque value after the intervention and the primary torque (or primary detorque) value. According to Goheen et al [20], a tool used for this purpose must be able to calibrate the applied torque. Also, Cibirka and Nelson [21] concluded that fixture-abutment connection type did not affect the detorque value after five million loading cycles. However, Aboyousssef et al. [17] concluded that addition of anti-rotation part increases the effect of preload and decreases the risk of screw loosening. Tzenakis et al. [22] assessed the effect of repeated torque and saliva contamination on preload of gold screw and showed that repeated use of saliva-lubricated gold screw resulted in higher preload. However, Byrne et al. [23] assessed the effect of repeated tightening of abutment screw on preload and concluded that applying repeated torque (repeated unscrewing and screwing) decreased the preload; this finding is different from that of Tzenakis et al. [22]. Nigro et al. [24] compared the wet and dry environment during tightening of abutment screw and reported that wet group (abutment screw contaminated with saliva) showed significantly higher detorque value after 10 times tightening and loosening compared to the dry group. Since a great part of the torque applied for screw tightening is used to overcome friction, they concluded that lubrication of screw with saliva decreases the friction and increases the preload. Cantwell and Hobkirk [25] evaluated the effect of time on preload loss and showed that after tightening of gold screw, the amount of primary preload decreased over time such that about 40% of preload was lost during the first 10 seconds and this trend continued for 15 hours. Takuma and Hagiwara [16] and Khraisat et al. [19] in their studies on the effect of lateral loads applied in cyclic loading showed a reduction in primary detorque compared to primary torque value. In the study by Takuma and Hagiwara [15], secondary detorque value showed an increase compared to primary detorque value after cyclic loading. In the study by Khraisat et al. [19] application of lateral loads perpendicular to the implant axis decreased the secondary detorque value compared to baseline; however, application of off-axial lateral loads did not decrease the detorque value. The above-mentioned studies all showed the eroding nature of preload. Thus, it is important to obtain the required preload and eliminate factors (mainly due to inappropriate prosthetic treatment planning) that result in preload loss and screw loosening.

The abutment-fixture interface should be clean at the time of screwing the abutment to the fixture because foreign body at this site can cause misfit and subsequent complications. Gingival tis-

sue, cotton pellet and gauze at the fixture opening are often easily detected by the naked eye and removed. However, presence of saliva or blood in this area is often neglected especially in submerged or platform switched implants. Repeated rinsing and drying may not be able to efficiently eliminate saliva and blood especially in the mandible. This process may even result in further bleeding into the fixture. Thus, the effect of contamination of the abutment- fixture interface on the fit of components and preload has always been a concern for clinicians. Since risk of contamination is higher in use of bone-level implants, Implantium system was used in the current study. Also, electronic torque meter was used for the purpose of calibration. In our study, the primary detorque value decreased compared to the primary torque, which was in agreement with the results of Takuma and Hagiwara [16] and Khraisat et al. [19]. Despite the application of the same torque value when tightening the screws, the primary detorque value was not the same for all abutment screws. This may be due to slight differences between the screws in terms of finishing, causing slight differences in preload [19]. Therefore, the final detorque value for each screw was compared with the primary detorque value of the same screw. After cyclic loading, the detorque value decreased by 42 to 52% in all groups, which was significant compared to the primary detorque value. Nigro et al. [24] also showed a reduction in detorque value; however, they used gold screw in their study, assessed the effect of repeated tightening and loosening and did not perform cyclic loading. It appears that greater reduction in detorque value in our study compared to that of Nigro et al. [24] is due to the effect of cyclic loading.

Cantwell and Hobkirk [25], Ortorp et al. [26] and Byrne et al. [23] measured the preload using a strain gauge and concluded that repeated tightening and loosening of screw and time decrease the preload. However, they did not perform cyclic loading. In our study, the detorque value decreased in all three groups after cyclic loading. The greatest detorque value was noted in group C and the lowest in group B. However, this difference did not reach statistical significance. This was in contrast to the results of Nigro et al. [24] who found a significant difference in detorque value between the saliva-contaminated group and the isolated, dry group. Difference between their results and ours may be due to relatively small sample size in our study.

Better simulation of the oral clinical setting by saliva and blood contamination of the interface and conduction of cyclic loading were among the strengths of our study. However, this study had limitations as well. For instance, use of detorque value indirectly shows the presence and function of preload while strain gauge accurately measures the magnitude of preload; however, changes after cyclic loading could not be calculated by use of a strain gauge. In removal of abutment from the fixture (for subsequent saliva/blood contamination), only one abutment was easily separated from the fixture and the remaining required high amounts of load for retrieval. This was thought to be due to gold welding. However, if that was the case, we expected the final

detorque value to be significantly different in the control group (since primary retrieval was not performed in the control group); but no significant difference was noted in this regard. On the other hand, this finding alone does not translate to inefficacy of gold welding for attachment strength. Another study is recommended to assess the load required for separation of abutment from the fixture in a large number of samples after cyclic loading. On the other hand, continuous presence of saliva in the oral environment could not be simulated in our *in vitro* study, which was another limitation of this study, limiting the generalization of results to the clinical setting. Furthermore, we had six samples in each group. However, only four samples could be subjected to cyclic loading at the same time. Thus, all six samples could not be subjected to cyclic loading simultaneously. Further studies with larger sample size are still required to obtain more reliable results. Moreover, biological effects of saliva and blood contamination of the interface should be evaluated and compared with isolated state.

## Conclusion

Within the limitations of this study, the results showed that presence of saliva and blood at the abutment- fixture interface did not have a significant effect on the detorque value after cyclic loading.

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